AGRICULTURAL ENGINEERING

NOVEMBER • 1953

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by Infrared Radiant Energy

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Infesting Wheat and Flour

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Flow Patterns of Air Through Grain
During Drying Process

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Water Rights and Administration in
Soil and Water Conservation

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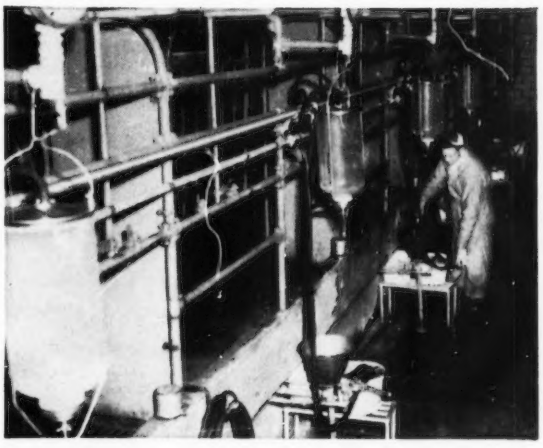

MILKING PARLOR at Rockacres Farm relies heavily on Stainless Steel, too. Milk enters Stainless teat cups and passes through Stainless pipe to the Stainless Steel cooling and holding tank. Sixty-five cows are now milked daily, and the herd is being greatly enlarged. The increase in herd size is made possible through the use of these modern methods of milk production.

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Established 1920

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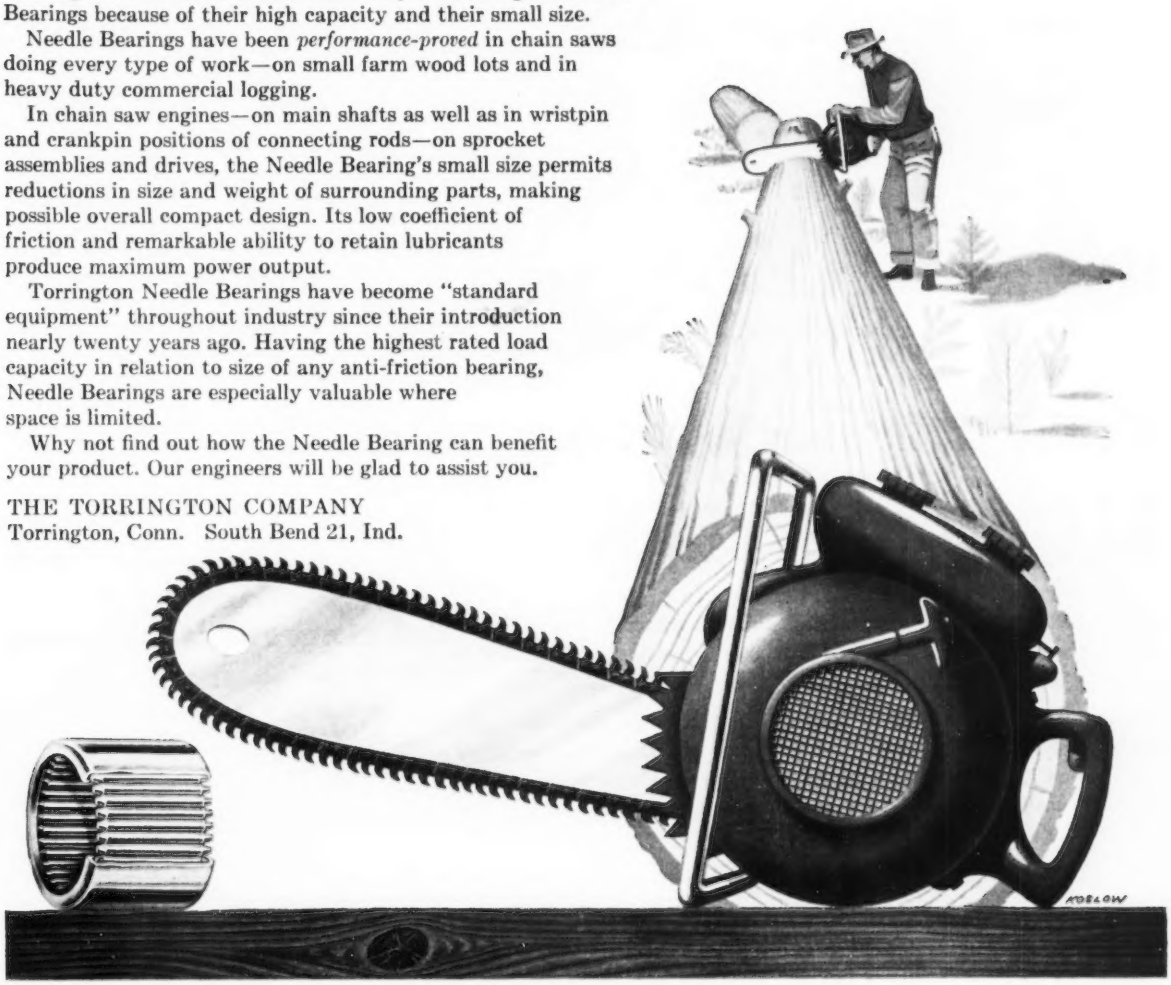

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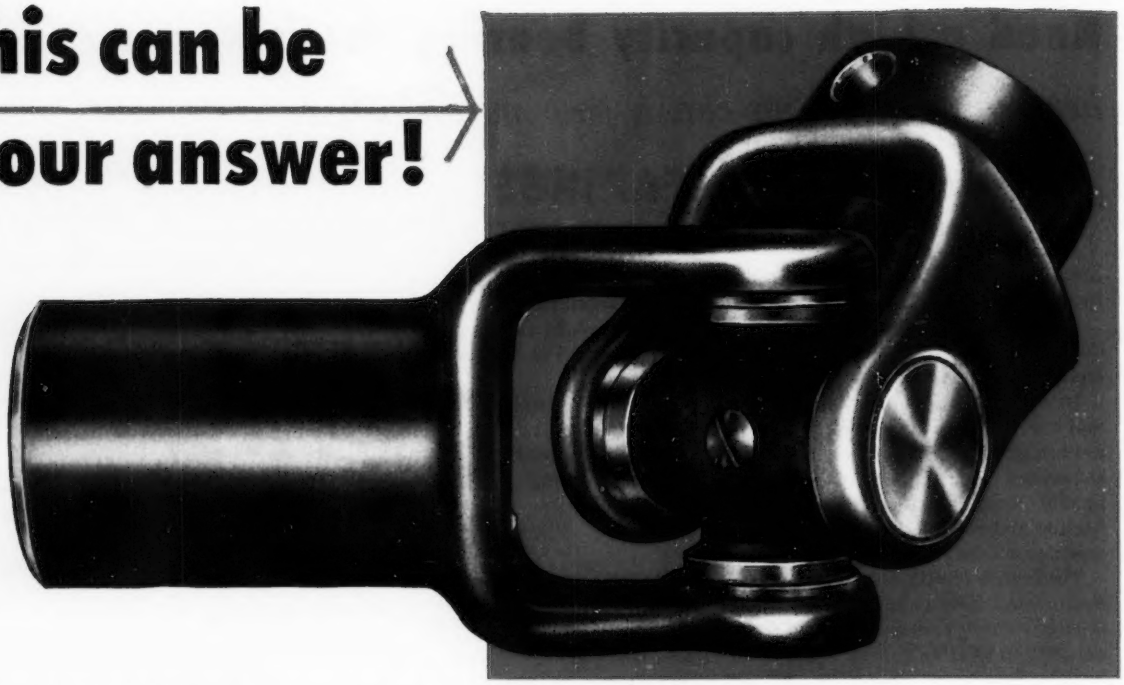

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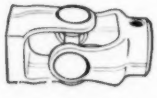

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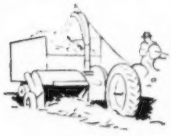
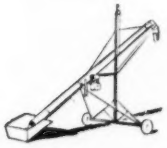
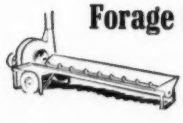


Forage harvesters

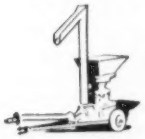


Grain loaders



Forage blowers

Post hole diggers



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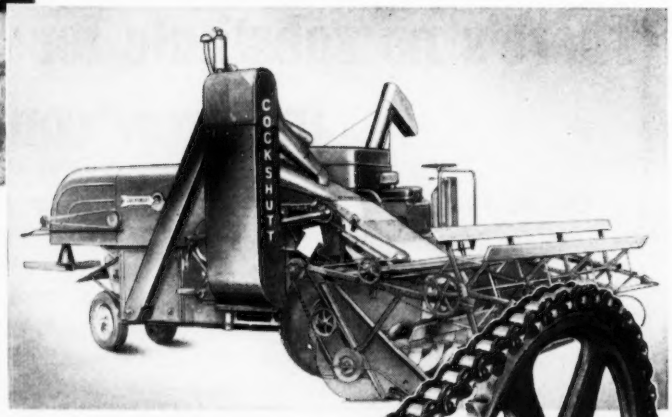

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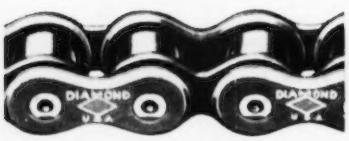

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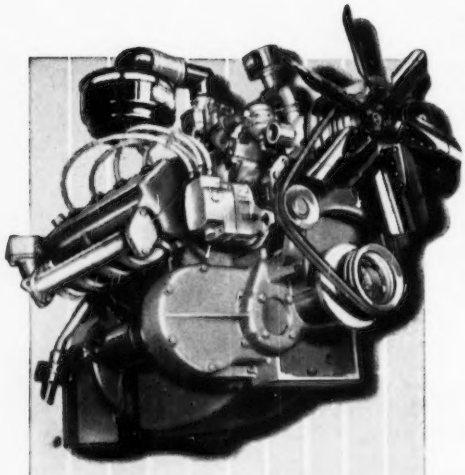
Photo courtesy Hale Fire Pump Company, Conshohocken, Pa.

Chrysler Power provides modern solution to age-old problem of irrigation



Early last summer, the owner of this 640-acre farm near Williamsburg, Virginia, decided to irrigate 120 acres. Taking his water from the nearby James River, he irrigated 70 acres of corn, 50 acres of soy beans. Water was pumped at the rate of 960 gallons per minute, fourteen hours a day, seven days a week. Each acre required approximately 36,000 gallons.

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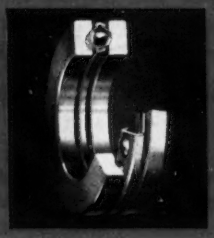

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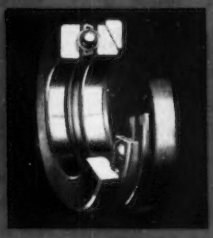

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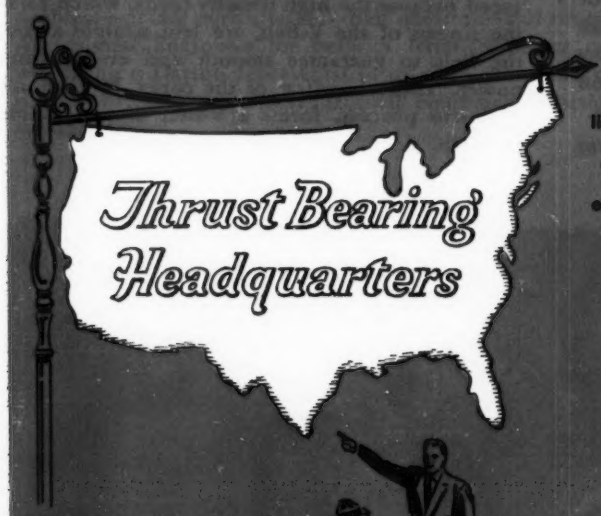

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Early experiments proved ordinary V-Belts were completely inadequate for this type of operation. V-Belts designed to withstand either tension or compression alone suffered excessive breakage when subjected to the stresses of *both*. It became clear specialized V-Belts were needed to withstand the punishment meted out by the back side idlers.

To meet the rugged requirements of such farm implement drives, Dayton Agricultural engineers developed the Dayton B.S.I. (Back Side Idler), designed and processed it to take the rigors of reverse bending right in stride.

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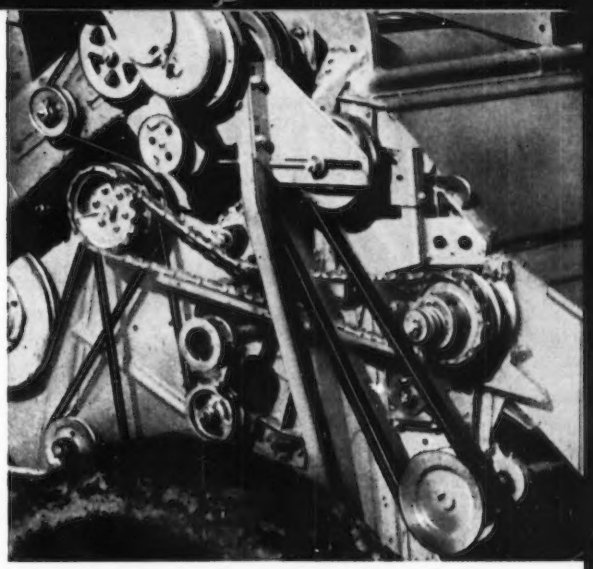
*T.M. Back Side Idler



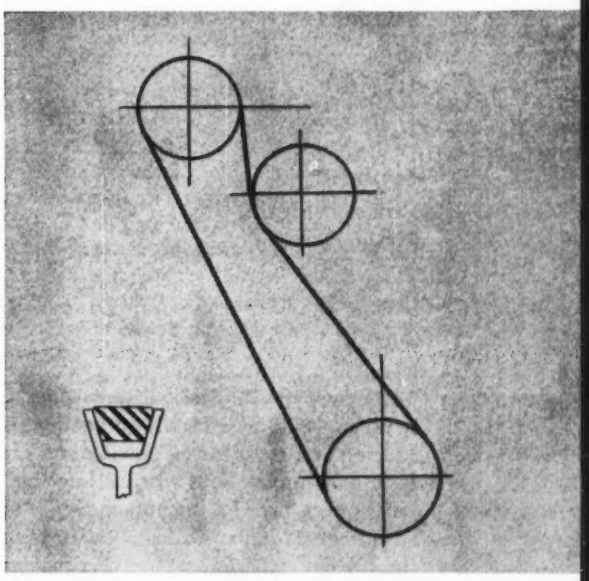
Back Side Idler Belt provides adjustment for fixed center drive for self-propelled combine.

In designing drives with immovable centers where periodic adjustment is necessary, even though the centers are fixed, the use of Dayton B.S.I. is especially recommended. Where small diameter pulleys are required, this Dayton V-Belt has been equally successful in transmitting power to meet all demands.

More and more, design engineers are specifying the Dayton Back Side Idler V-Belt. Manufacturers, too, are including the Dayton B.S.I. as a standard component part on new equipment to insure longer life, dependable power, freedom from excessive breakage, and lower replacement cost.

The Dayton B.S.I. is a typical example of how Dayton Agricultural Engineers and Dayton research work hand in hand with original equipment manufacturers and design engineers to solve the problems encountered in farm machinery development.

If you are confronted with a back side idler power problem—or *any* agricultural V-Belt question—call on our Agricultural Engineers for help. A letter, wire, or call will bring a Dayton representative to place the entire resources of our Agricultural Original Equipment Division at your service.



Schematic drawing diagrams dual purpose application of Dayton B.S.I. V-Belt.

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For complete information on all types of Agricultural V-Belts, send for Dayton's newest folder. Write direct to:

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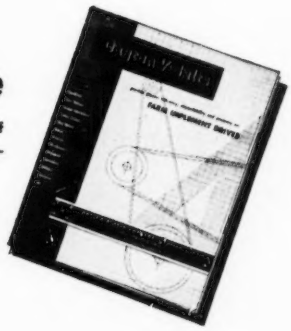
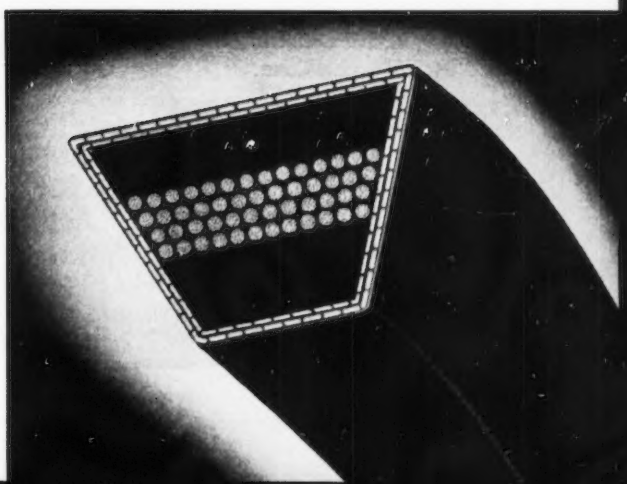


The Dayton Back Side Idler V-Belt is a wrapped, molded belt, manufactured of highest quality rubber, specialized cord and fabric. Laboratory tested and farm proved, the Dayton B.S.I. is the answer to fixed center drives where belt adjustment is required.



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ANOTHER NEW FAFNIR...

Ball Bearing "Economy Package"

Type PB Pressed Steel Pillow Block

The new Type PB Series Pillow Block is developed to fill a specific need for a high-quality, precision ball bearing unit at the lowest possible cost. It is made for *light duty* applications where a low-cost "packaged" unit offers definite manufacturing and servicing advantages . . . on agricultural equipment, conveyors, light-duty fans and similar types of machinery involving the transmission of power.

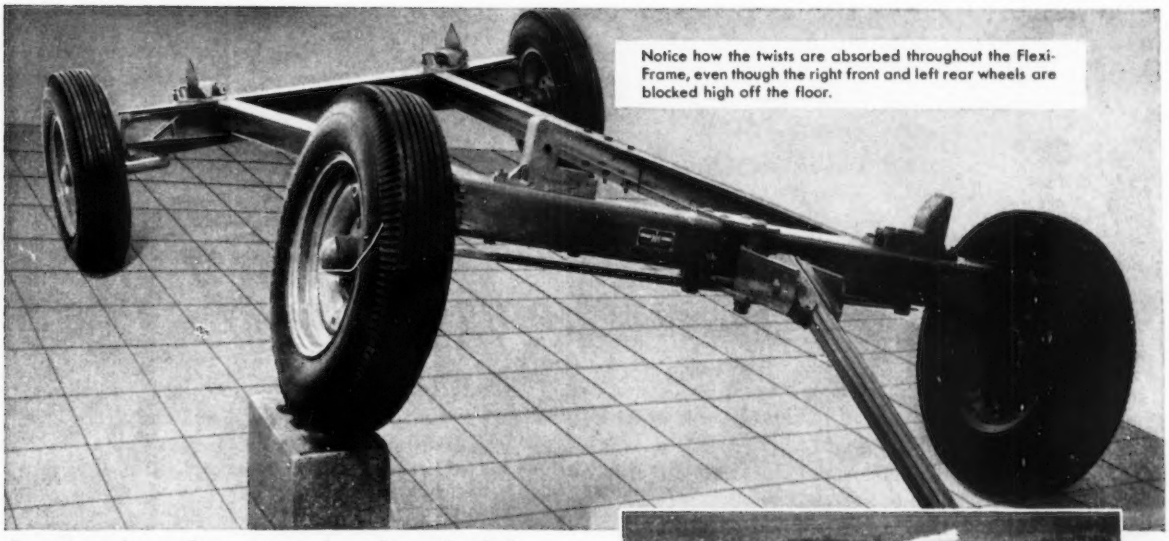
The Type PB Series Pillow Block opens up new opportunities to add extra product sales features and to lower maintenance costs . . . another example of the Fafnir "attitude and aptitude". Send for new, descriptive bulletin. The Fafnir Bearing Company, New Britain, Conn.

OUTSTANDING FEATURES

- Low Cost
- Precision Ball Bearing . . . Fafnir Wide Inner Ring Bearing* with Self-locking Collar and efficient Plya-Seals.
- Two-piece separable pressed-steel housing.
- Self-aligning . . . unrestricted in all directions at assembly.
- Occupies less space than other pillow blocks.
- Light weight . . . combined with ample strength.
- Only two bolt holes required in assembly.
- Ample capacity for radial, thrust or combined loads.
- Pre-lubricated with long-life grease.
- Available for shaft sizes ½" to 1¼" inclusive.

*Easiest bearing of all to install. Counterbored, eccentric, mated cam construction of collar and inner ring assures positive locking action without set screws, lock nuts or adapters.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA



Notice how the twists are absorbed throughout the Flexi-Frame, even though the right front and left rear wheels are blocked high off the floor.

A report to you about men and machines that help maintain International Harvester leadership

FLEXI-FRAME

developed for new McCormick No. 52 tractor trailer gives fast, safe "floating ride" hauling

Here's the No. 52 on a steep roadside grade. Even though the left rear wheel is much lower than the right, the load on the platform "stays put." No matter how uneven the ground, the load is never "tippy."

An all-new principle of wagon design has been developed by International Harvester engineers to make modern farm hauling safer, easier and faster.

The new design includes Flexi-Frame construction, with twin-channel section reaches, to absorb shock and twists. Flexi-Frame causes wheels to glide—instead of bounce—over rough ground with "floating ride" smoothness.

Fixed box supports distribute the load on the axles to reduce tipping and rocking. Also, wide 68-inch tread and low-built design gives the wagon maximum stability with all types of loads.

Auto-type steering with protected, steel-plate tie bar gives the front end extra strength—yet makes turning easier and eliminates road-sway. The section reaches, sag-proof axles and high-carbon steel spindles are IH quality-built to give many years of trouble-free service.

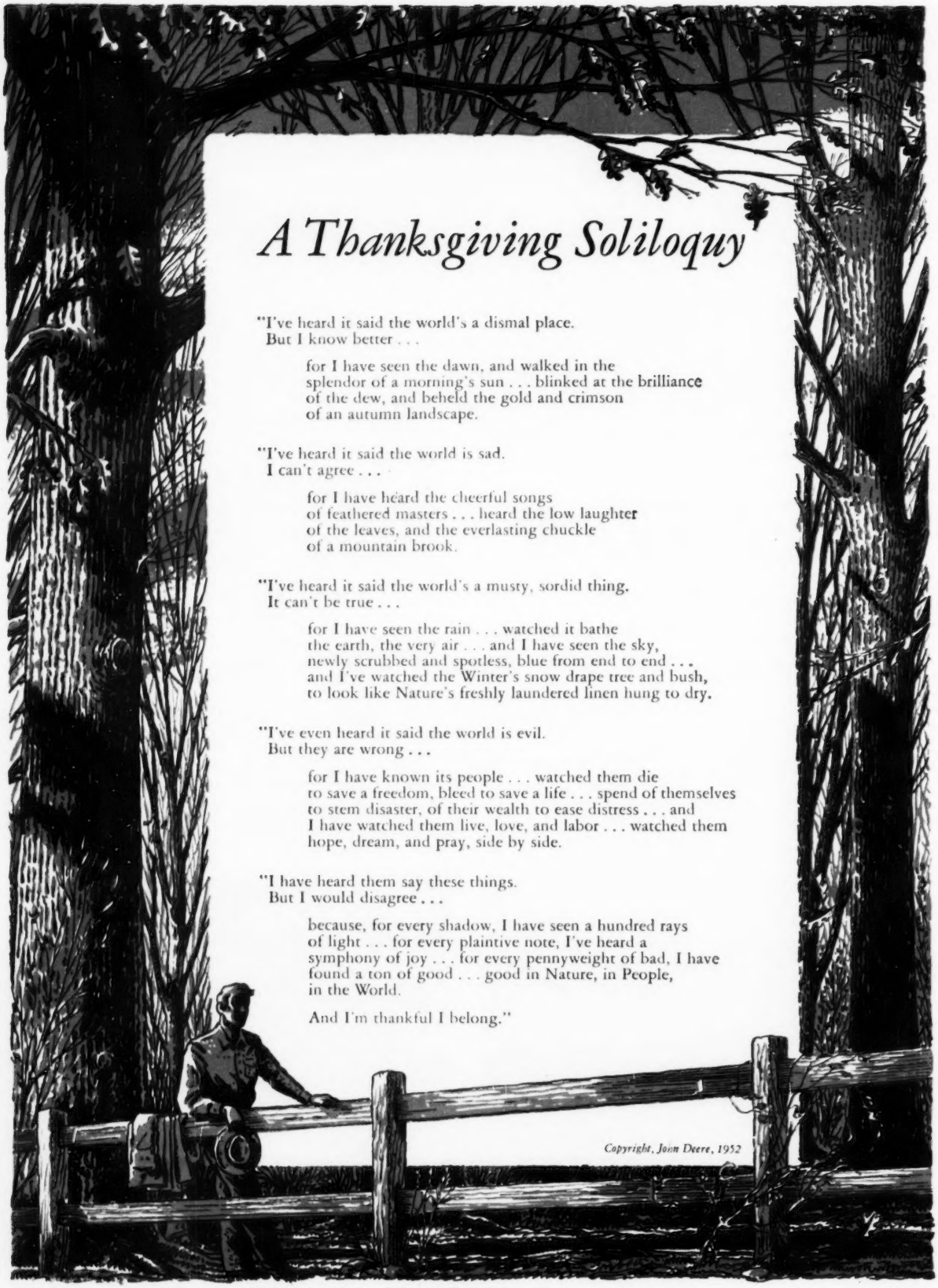
With sides on, the No. 52 Tractor Trailer and McCormick No. 10 box makes an ideal combination for hauling grain, feed, fertilizer.

With sides, off, the No. 10 is an easy-to-load platform carrier only 31 inches high—ideal for hauling boxes, crates, baled hay, straw.

IH engineering teamwork produced the new Flexi-Frame design for the No. 52 tractor trailer. IH research, engineering and manufacturing men are constantly pooling their time and talent to solve farm problems—to provide equipment that makes farm work easier and the farmer's time more productive!

INTERNATIONAL HARVESTER

International Harvester products pay for themselves in use—McCormick Farm Equipment and Farmall Tractors . . . Motor Trucks . . . Crawler Tractors and Power Units . . . Refrigerators and Freezers—General Office, Chicago 1, Illinois



A Thanksgiving Soliloquy

"I've heard it said the world's a dismal place.
But I know better . . .

for I have seen the dawn, and walked in the
splendor of a morning's sun . . . blinked at the brilliance
of the dew, and beheld the gold and crimson
of an autumn landscape.

"I've heard it said the world is sad.
I can't agree . . .

for I have heard the cheerful songs
of feathered masters . . . heard the low laughter
of the leaves, and the everlasting chuckle
of a mountain brook.

"I've heard it said the world's a musty, sordid thing.
It can't be true . . .

for I have seen the rain . . . watched it bathe
the earth, the very air . . . and I have seen the sky,
newly scrubbed and spotless, blue from end to end . . .
and I've watched the Winter's snow drape tree and bush,
to look like Nature's freshly laundered linen hung to dry.

"I've even heard it said the world is evil.
But they are wrong . . .

for I have known its people . . . watched them die
to save a freedom, bleed to save a life . . . spend of themselves
to stem disaster, of their wealth to ease distress . . . and
I have watched them live, love, and labor . . . watched them
hope, dream, and pray, side by side.

"I have heard them say these things.
But I would disagree . . .

because, for every shadow, I have seen a hundred rays
of light . . . for every plaintive note, I've heard a
symphony of joy . . . for every pennyweight of bad, I have
found a ton of good . . . good in Nature, in People,
in the World.

And I'm thankful I belong."

Copyright, John Deere, 1952

JOHN DEERE • MOLINE, ILLINOIS • *Quality Farm Equipment Since 1837*

DEEP TILLAGE BRINGS HOPE TO DROUGHT-DISASTER AREAS

Bone dry, burned out, baked "hard as a brick," Texas land will turn green again next spring, even with less than normal rainfall.

Caterpillar Farm Tractors hauling giant disk plows are slashing their way through packed, drought-disaster land to condition the soil 14"-16"-18" deep for wheat, cotton, or range. This will speed up crop growth and range improvement. Land where grass roots *have died* will carry cattle in a year or so. Sandy soil will be turned and tied down to stop a 1954 "Dust Bowl".

Leading the deep tillage attack are Caterpillar Diesel Tractors . . . the one tractor with the guts to take the punishment of 24 hour, full load work, year after year.

Proof of long life comes from the many Cat® Diesel Tractors that have worked for 50,000 or more actual field hours. The longest work record ever reported for a farm tractor is held by a Cat Diesel Tractor that has actually worked more than 80,000 hours . . . equal to 100 years of service on the average farm!

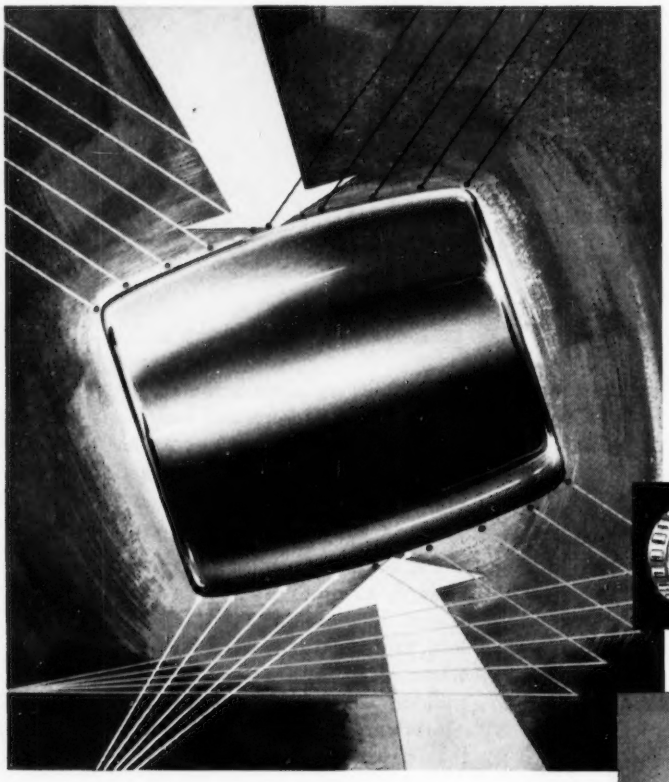
Big scale deep tillage has to be done cheaply to break even . . . Caterpillar Diesel Tractors work for 60% to 80% less fuel cost than ordinary gasoline wheel tractors. Up to 32,900 pounds of pull on the drawbar, so Caterpillar owners accomplish far more work than they can with wheel tractors.

On the burned out Texas plains . . . as elsewhere . . . farmers are turning to the most efficient farm tractors, capable of helping to produce bigger yields at less cost . . . with less labor. That's the job tailor-made for a Cat Diesel Tractor!

Caterpillar Tractor Co., Peoria, Illinois

CATERPILLAR®

DIESEL FARM TRACTORS



A new era in bearings is taking this shape...

NEW HYATT BARREL BEARING

now available in volume!

Industrial designers and engineers seldom make changes in bearing specifications. But when they discover something *really new*—like Hyatt's BARREL BEARING—out come the blueprints! *And this time they know they've got something!* Hyatt's new Barrel Bearing combines dual-purpose design with self-aligning action. It takes load from any direction and operates at full efficiency under conditions of misalignment! And, because barrel-shaped rollers provide high load capacity with low friction, this unique bearing is ideal for a wide range of applications. Best of all, the *cost* is far lower than you would expect! Find out how to improve *your* product . . . Consult a Hyatt Sales-Engineer, or write for our new Barrel Bearing catalog.

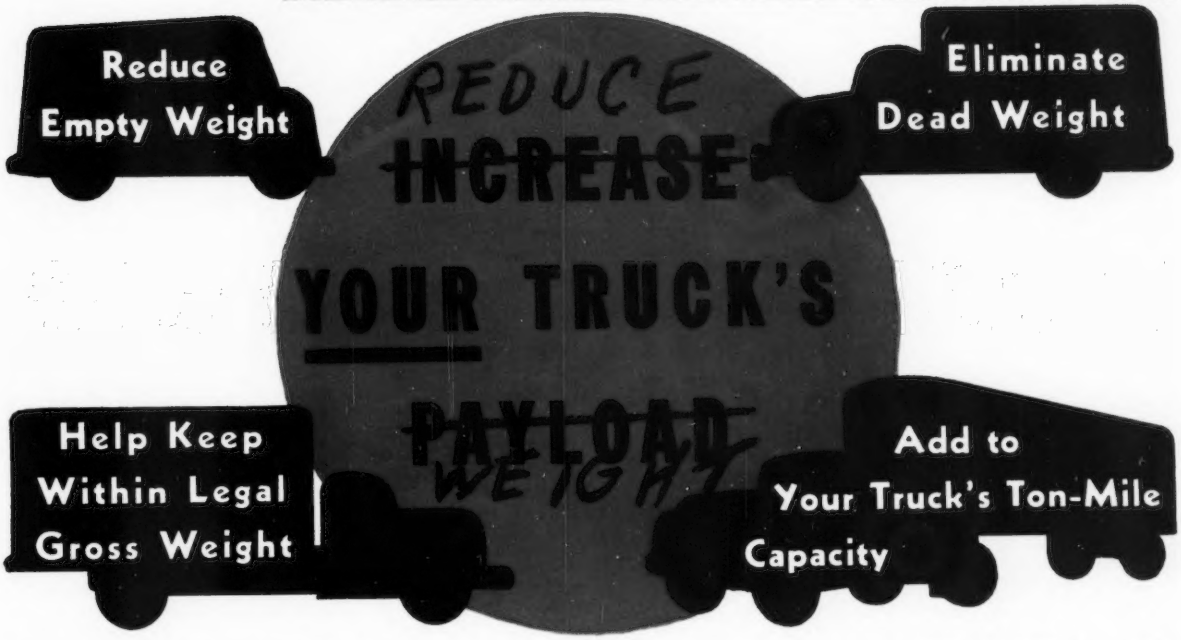
HYATT ROLLER BEARINGS

STRAIGHT · BARREL · TAPER

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION, HARRISON, N. J.

FLASH .... FLEET OPERATORS ARE PAYING A PREMIUM

OF ONE DOLLAR PER POUND FOR REDUCED TRUCK WEIGHT



A truck manufacturer says big fleet operators are offering $1.00 per pound for reduced truck weight — and that the use of lighter metals has reduced weights down to their lowest achievement point — within acceptable standards of life and wear. Because MECHANICS Roller Bearing UNIVERSAL JOINTS truck PROPELLER SHAFT is pounds lighter than other joints and shafts of comparable torque capacity — you can reduce the weight of *your* truck by specifying MECHANICS. Let MECHANICS engineers help reduce the weight and increase the payload capacity of *your* truck — and give it a competitive weight advantage — with a MECHANICS Roller Bearing UNIVERSAL JOINTS truck PROPELLER SHAFT application.

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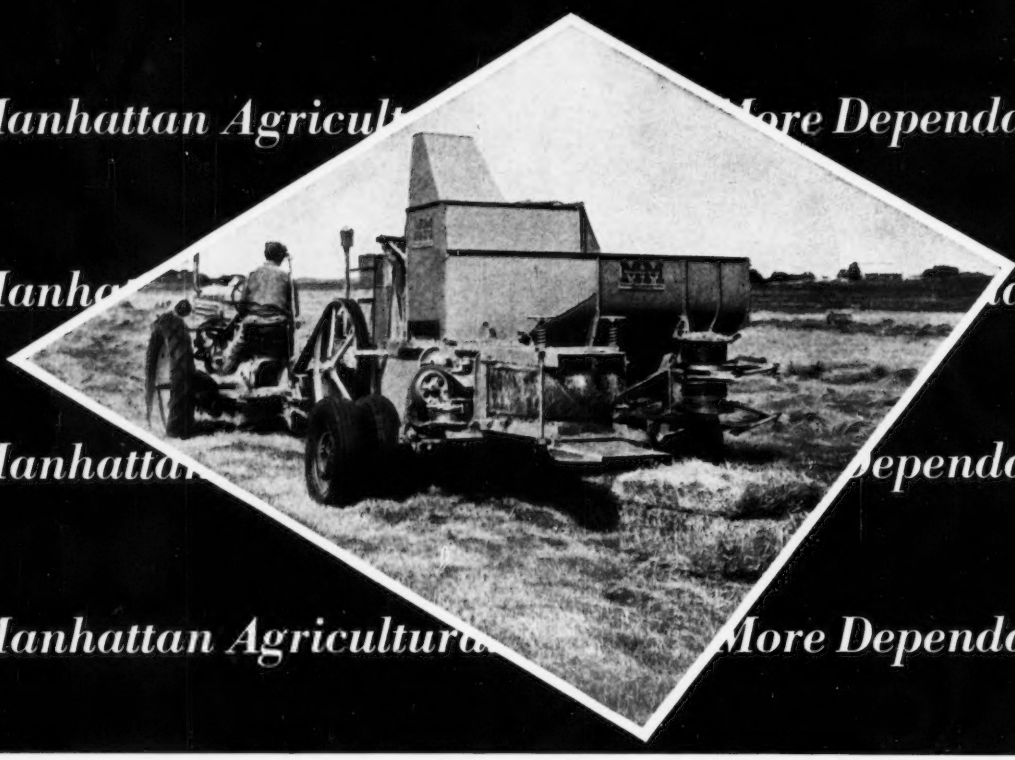
Manhattan Agricultural Belting—More Dependable



Manhattan Agricultural Belting—More Dependable

UNDER ALL OPERATING CONDITIONS, and on all types of power applications, Manhattan Agricultural Belts have won the confidence of Farm Equipment Manufacturers. The engineered features of strength, flexibility, and long-life which are built into these belts account for their consistently uniform performance and their day-in, day-out dependability on the job.

Manhattan's 60 years of pioneering research and development has produced the most reliable and economical agricultural rubber products in the field today. Designed to meet rigid manufacturers' specifications, Manhattan Agricultural Belts are continually contributing to the success of farm equipment by making power drives as nearly foolproof and trouble-free as possible.

Manhattan is always ready and eager to help specify the proper belt for your needs and to work with your engineers on the design of new power transmission drives. Call us at any time. There is no obligation.

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MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

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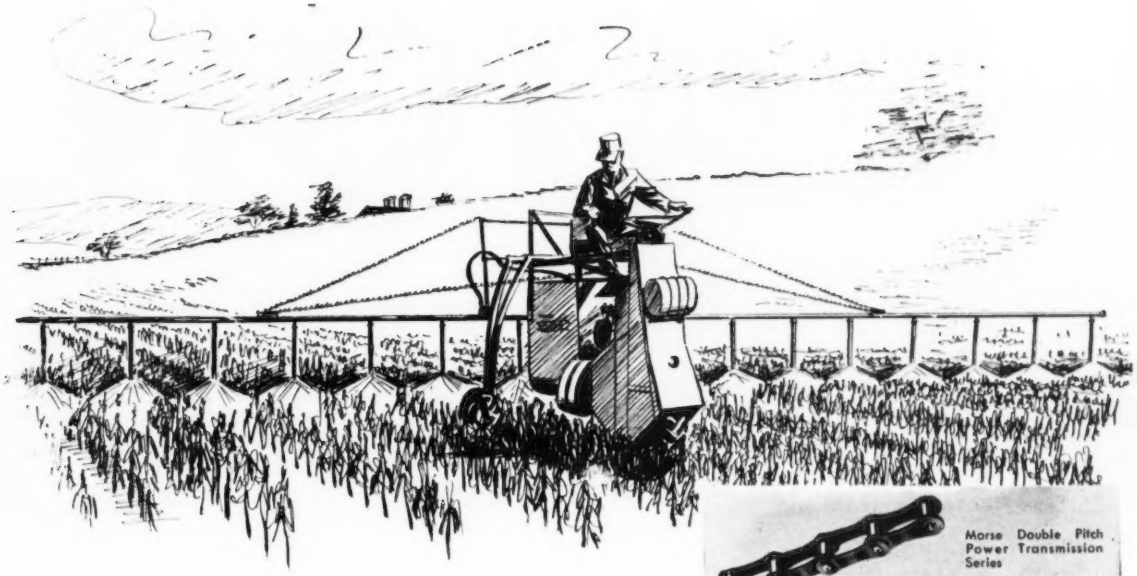

Morse Double Pitch Power Transmission Series

Morse Double Pitch Standard Chain—with attachments. Available with belt or straight attachment plates, one or two attachment holes, standard or large rollers. Pitch sizes from 1" to 2½".

Quick refresher facts

ON MORSE DOUBLE PITCH CHAINS

You gain parts economy and increased customer satisfaction when you equip your farm machinery with Morse Double Pitch Chains

DESIGN, ECONOMY FACTORS

You cut problems raised by gradual pitch elongation to a new low with these tough, precision-built, steel chains. Your customers will welcome freedom from maintenance cost, time loss and annoyance

Morse Double Pitch Chains come in two series. *Power Transmission* and *Conveyor*. Both series are adaptable to a maximum range of applications, can be used with standard and special attachments

Double Pitch Chains are ideally suited for applications where rotative speeds are low and the power to be transmitted is within the capacity of a single strand chain. In comparison with standard roller chains, they weigh less, cost less; with proper care, they provide the same long life. Parallel strands wear evenly—a particular advantage for conveying work.

STAMINA FACTORS

Morse Double Pitch Chains will wear longer, give more satisfactory all-round performance, help reduce downtime. Here are a few reasons:

1. PINS. Heat-treated special high-nickel, fine grain alloy steel pins have extremely hard case for wear resistance, tough inner core for high strength.

2. PIN LINKS. In Morse Double Pitch Chains, heavy press fit holds pins immobile in pin link plates. Accuracy of assembly and close fit tolerance of pin and plate components assure proper clearances between pins and bushings.

3. BUSHINGS. Morse bushings are case hardened and heat treated for maximum wear. Smooth inner bearing surfaces and true roundness help eliminate pin scoring, increase joint life, reduce elongation.

4. ROLLERS. Rollers, processed from special alloy steel, are shot-peened for maximum wear and resistance to shock.

5. LINK PLATES. Morse link plates are specially treated to obtain maximum structural strength and maximum endurance qualities necessary in highly stressed tension parts.

If you'd like sound, effective engineering help on drive design, attachment selection, or any related mechanical-power-transmission problem that's bothering you, let us put you in touch with one of our skilled Morse Men. Or, write for Catalog C52-52. MORSE CHAIN COMPANY, Dept. 547, 7601 Central Ave., Detroit 10, Michigan.

M=PT
MORSE *means* POWER TRANSMISSION

MORSE
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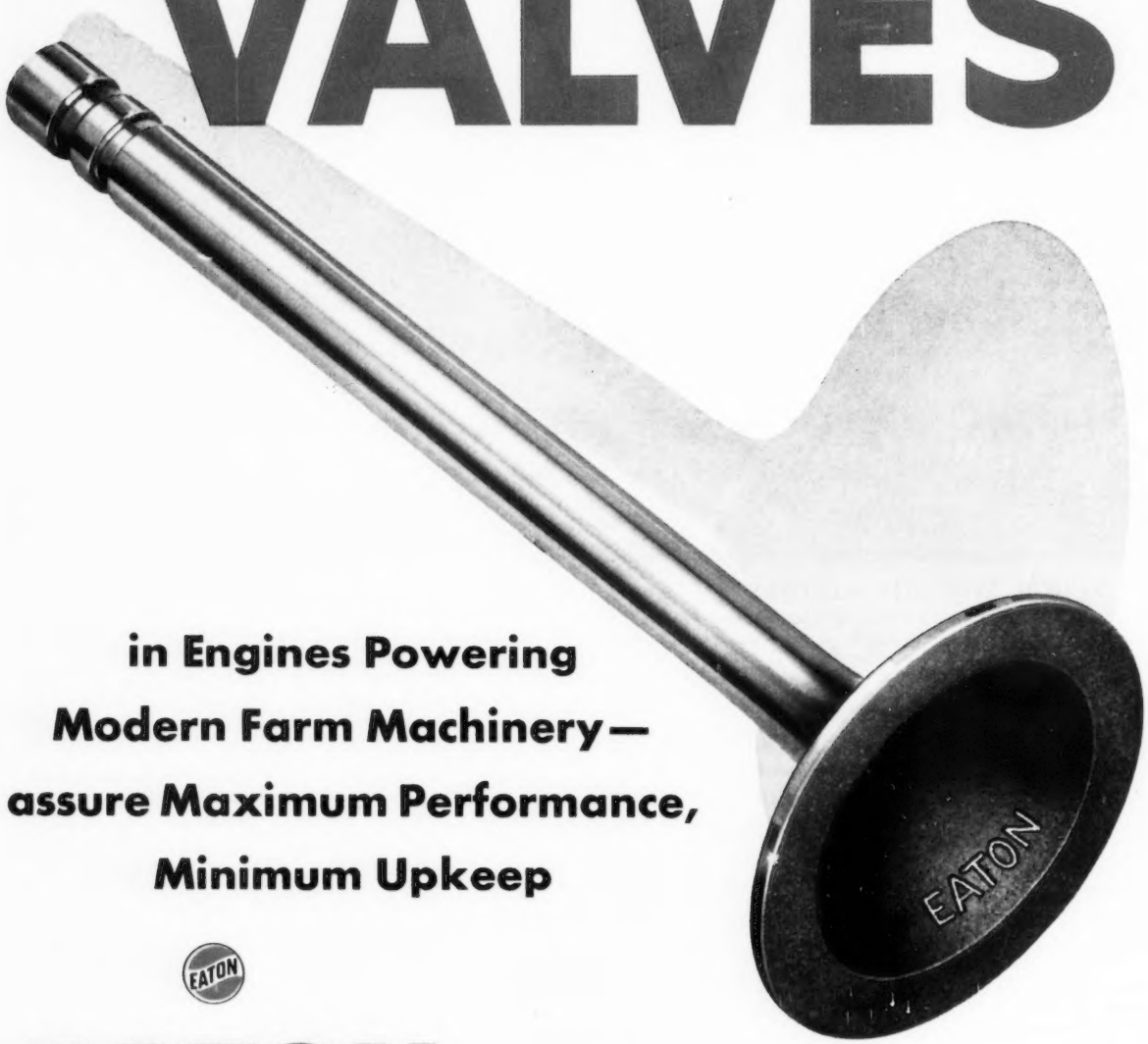
MECHANICAL POWER TRANSMISSION PRODUCTS

EATON VALVES



in Engines Powering Modern Farm Machinery— assure Maximum Performance, Minimum Upkeep

EATON MANUFACTURING COMPANY

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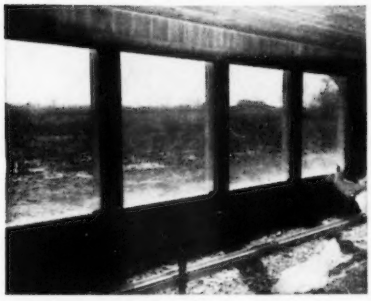
EATON PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Farmers Report Success with THERMOPANE* INSULATING GLASS



POULTRYMAN

Harvey L. Hunt,
Fairfield, Iowa

"Egg production remains at a steady level, with no slump whatsoever because of cold weather. I am sure feed is saved by the temperature in the house remaining up in winter. Also, there is less artificial light required on short winter days. Greatest labor savings is the fact that litter does not have to be changed. The fixed *Thermopane* windows make ventilating easier because they practically eliminate rapid temperature changes. All noises are deadened, passing trains and such noises don't disturb the hens."

DAIRYMAN

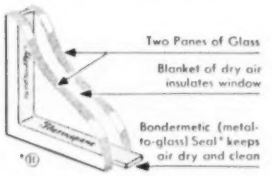
John Barringer,
Fostoria, Ohio

"*Thermopane* in my remodeled milkhouse and milking parlor improved wintertime warmth to the point that no auxiliary heat was necessary in the winter of 1952-53. Milking parlor floor dries rapidly after being washed down. Summertime coolness was very noticeable. Because of less humidity, building is easier to keep clean. Working areas are daylighted much better, creating more cheerful atmosphere. *Thermopane* improves the building appearance and provides a more attractive showing of livestock."

HOG BREEDER

Howard Roach,
Plainfield, Iowa

"With outside temperatures as much as 25 degrees below zero and heat lamps as only source of artificial heat, inside temperatures haven't gone below freezing the past three winters. Bedding is kept dry, with minimum of offensive odors. Tenant farmer says he has never worked in such pleasant conditions in animal shelters. Very little condensation. Windows stay clean longer."



These are just a few of the many reports received from farmers who have used *Thermopane* insulating glass. These are their own statements, not ours. Identical gains in production—identical savings—of course, cannot be expected by everyone. That is because the benefits received result from many factors, which vary by climate and local conditions. But these reports are assurance of good results—assurance of conditions conducive to increased production and better livestock health—assurance that you can recommend *Thermopane* with confidence. We have prepared books on *Thermopane's* benefits in livestock raising. Mail the coupon for your copies.

SOLAR FARM BUILDING PLANS

The Better Farm Buildings Association has prepared complete plans. Working drawings, plus a complete list of materials, are available from Libbey·Owens·Ford at $2 per plan.

LOF GLASS FIBER-GLASS

Thermopane
INSULATING GLASS

Libbey·Owens·Ford Glass Company
18113 Nicholas Bldg., Toledo 3, Ohio

Please send me:

☐ A free folder on *Thermopane* for dairy, hog and sheep, poultry. (Circle choice)

Plans for:

☐ Dairy barn ☐ Hog house
☐ Milkhouse ☐ Poultry laying house
☐ Calf barn ☐ Broiler house

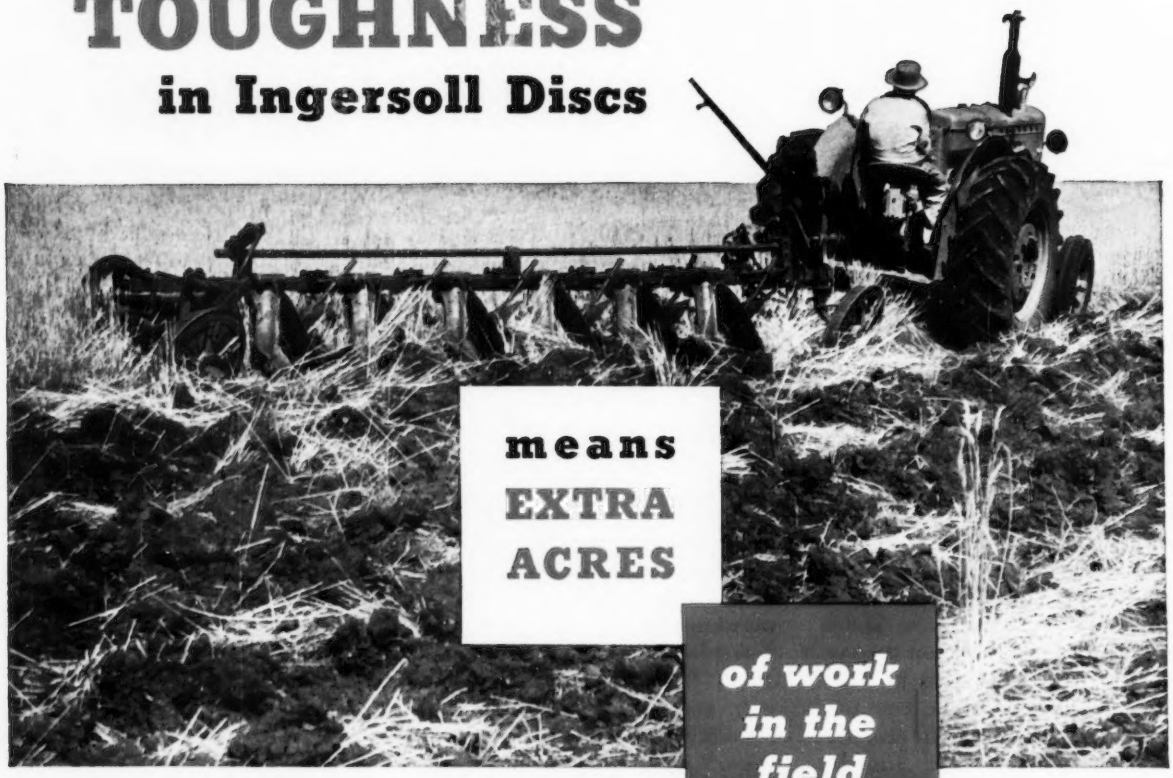
For which I enclose $2 each.

Name _____

Street or R.R. No. _____

Town _____ State _____

the EXTRA TOUGHNESS in Ingersoll Discs



Minneapolis-Moline Gasoline Tractor pulling MM TRA Plow equipped with Ingersoll Discs

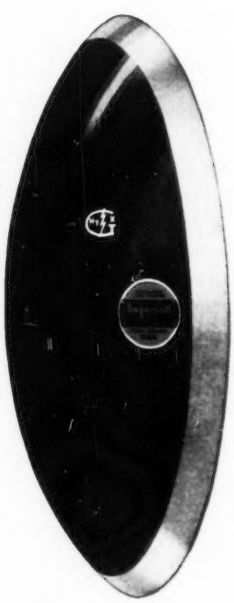
In three important ways, *extra toughness* is built right into every Ingersoll Disc.

1. The *extra toughness* of Ingersoll's own Tem-Cross steel—the result of special cross-rolling which prevents splitting or curling of the edges.
2. The *extra toughness* imparted by Ingersoll's special heat treat method, which results in greater uniformity, less stress and strain, and eliminates warping.
3. The *extra toughness* resulting from Ingersoll's unique *long draw* process, which assures proper hardness and maximum resistance to abrasion.

That's why Ingersoll Discs work so many more acres in the field. And *that's* why Ingersoll Discs are standard equipment on approximately 8 out of 10 tillage implements made today!

To give *your* customers this *extra toughness* for *extra* acres of work, *always specify Ingersoll Discs.*

Ingersoll
Heat Treated Discs



INGERSOLL PRODUCTS DIVISION
Borg-Warner Corporation
310 S. Michigan Ave., Chicago 4, Ill.

ENGINEERING B-W PRODUCTION

AGRICULTURAL ENGINEERING

VOL. 34 NOVEMBER, 1953 NO. 11

Control Equipment for Infrared Poultry Brooding

James M. Stanley and Vernon H. Baker
MEMBER ASAE ASSOC. MEMBER ASAE

DURING the past several years the use of infrared lamps as a method of brooding poultry has become increasingly popular. The control or regulation of energy for this type of brooding is somewhat different from that used with other brooding methods. Infrared lamp brooding is classed as cool room brooding and there is no chance of overheating when using lamps according to recommended procedures. Radiant energy is supplied to an area below the lamps and the birds select a spot with an energy level suited to their needs. The amount of energy required depends on the air temperature and drafts in the house, type of birds, radiation losses, feed, etc. A control system is then desirable that will automatically regulate the amount of energy available for brooding. The main purpose for control, if proper brooder management is being employed, is to conserve energy thus making this method of brooding more economical.

Since infrared lamps were first used for brooding, a common method employed for the control or regulation of their output has been by a wafer-operated snap-action switch or thermostat, as it is normally called. This control has been used to break the circuit to a portion of the lamps in the brooder, the number of lamps controlled being determined by the current-carrying capacity of the snap-action switch. This is the type of control most widely used. As can be clearly understood, the lamps not controlled by the snap-action switch remain energized at full intensity, while those that are controlled are completely de-energized. This results in a disturbance in the pattern of the heated area or comfort zone. Other control systems have been developed, employing transformers of various types that vary the voltage to the entire group of lamps that make up the brooder or brooders in a particular installation. With a 50 percent reduction in voltage on the lamps the radiation goes down approximately to one-fourth.

This paper is third in a series of reports on infrared brooding and covers results of tests on the wafer snap-action switch, the saturable core reactor, and the autotransformer that have been used in experimental infrared poultry brooding work at the Virginia Agricultural Experiment Station. Two previous reports (1, 2)* were presented in 1950 and 1951. All the projects have been conducted jointly by the agricultural engineering and poultry departments of the Station and the farm electrification division (BPISAE), U.S. Department of Agriculture.

Wafer Thermostat and Snap-Action Switch. The simplest form of a control is the thermostat consisting of a gas-filled wafer-sensing element which operates a snap-action switch (Fig. 1). This type unit is used on many of the brooders using four 250-w lamps. When used on this type of brooder, it is wired in the circuit with two of the lamps, usually diagonally opposite each other. The degree of saving in electrical energy will vary depending on the room temperature and thermostat setting. The thermostat should be adjusted so that all lamps will be energized when the room temperature is 70 F or below. This and other temperature references probably will have to be adjusted up or down depending on the thermostat location and demands of the birds.

Two 250-w lamps, or a total of 500 w, is the maximum wattage that is recommended to be controlled by a single snap-action switch on a 115-v circuit. Trouble with sticking contacts, due to surge current when the switch makes the circuit, has been reported by some poultry farmers when using these switches with loads of about 500 w. A manufacturer has recommended the use of switches with silver contacts or silver inserts as a means of preventing this trouble. The resistance of the cold tungsten lamp filament is only a small portion of the hot-filament resistance; therefore, when the circuit is closed and the lamp filament is cold, the current surge may reach a theoretical value of 12 to 16 times

*Numbers in parentheses refer to the appended references.

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at New Orleans, La., February, 1953.

The authors — JAMES M. STANLEY and VERNON H. BAKER — are respectively, associate agricultural engineer, farm electrification division (BPISAE), U.S. Department of Agriculture, and associate agricultural engineer on leave of absence from the Virginia Agricultural Experiment Station.

Acknowledgment: The authors acknowledge the contributions of J. H. Bywaters and C. E. Holmes, poultry department, Virginia Agricultural Experiment Station; W. D. Hemker, agricultural engineer, Westinghouse Electric Corp.; E. D. Nunn, president, Northern Signal Co., and Richard H. Martin, former student of agricultural engineering, Virginia Polytechnic Institute.

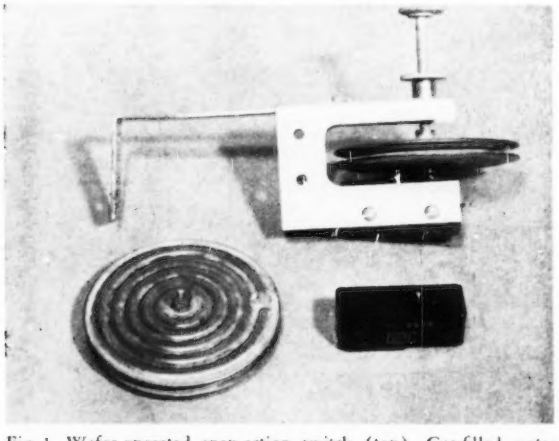


Fig. 1 Wafer-operated snap-action switch (top). Gas-filled water (bottom left) Snap-action switch (bottom right)

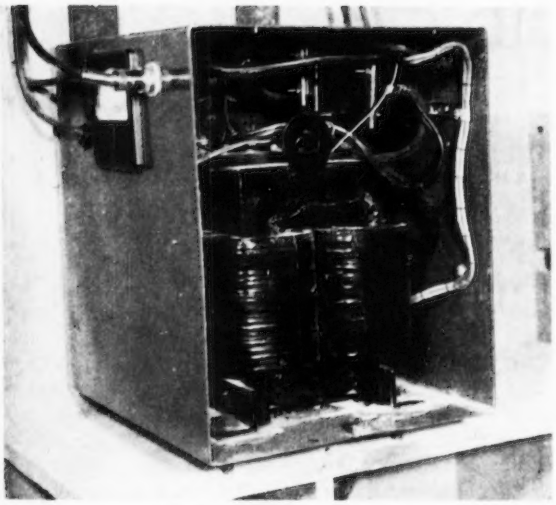


Fig. 2. Saturable core reactor

the normal current (3). Practically, the surge current is not quite this great.

For summer brooding it might be desirable to use two thermostats on the four-lamp brooder, each thermostat operating two lamps. The second thermostat could be replaced by a hand-operated switch. However, this would reduce the automatic-operation characteristics. If thermostats or switches are used to break circuits to all of the lamps, it is necessary that provisions be made for providing light when no heat is needed. This can be accomplished by using a double-throw switch to de-energize the last two infrared lamps and energize an attraction light, or by allowing the attraction light to remain on all of the time during summer brooding when all of the infrared lamps are likely to be de-energized.

For brooders using six lamps, two or more of the single-switch thermostats can be used. They should be adjusted so that all lamps are energized when the room temperature is 65 F or below. At temperatures from 65 F to 80 F four lamps should be energized. Above 80 F only two of the lamps should be energized. Again, if this size brooder is to be used during periods, such as in summer brooding, when

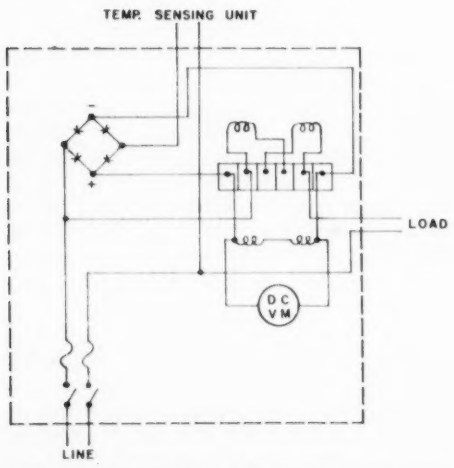


Fig. 3 Schematic diagram of saturable core reactor

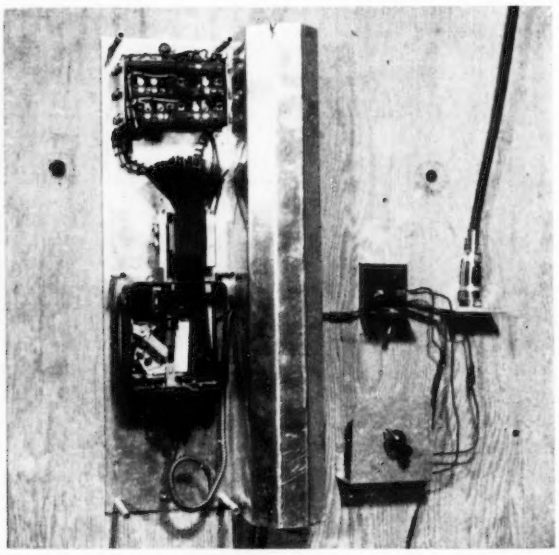


Fig. 4 Silverstat temperature-sensing element

no radiant energy from the lamps is required at times, it is necessary to provide a means for furnishing light in the brooding area when the infrared lamps are not energized.

One manufacturer has assembled a 3- and a 5-snap-action type control device. All snap-action switches are operated by a single wafer. Units of five switches work satisfactorily on a brooder with 12 lamps.

Saturable Core Reactor. During the 1952 late winter brooding season a 3-kva saturable core reactor built by the Westinghouse Electric Corp. was tested. The unit consisted of a reactor and a temperature-sensing element (Figs. 2, 3 and 4). The sensing element regulated the amount of current that was supplied to the core winding of the reactor, which determined the degree of saturation of the core. The degree of saturation of the core regulated the voltage that was supplied to the infrared load.

Furnished as a part of this unit was a vapor-bellows thermostat which actuated a Silverstat consisting of 40 leaf springs, each of which was connected to a risistor. As the leaf springs were actuated by the mechanical linkage from the thermostat, resistance was put into or taken out of the control circuit. This controlled the a-c current to the recti-

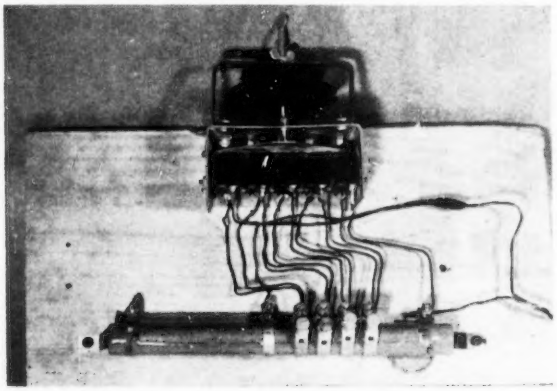


Fig. 5 Five-unit thermostatic control switch

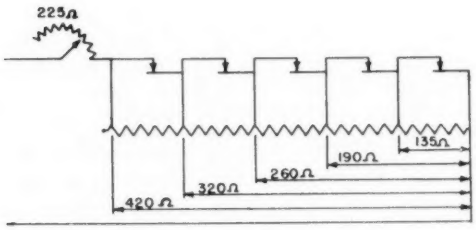


Fig. 6 Wiring diagram showing arrangement of variable resistor, snap-action switches of Beacon unit, and fixed resistances

fier which indirectly determined the degree of saturation of the reactor core.

In order to provide a simpler and less expensive temperature-sensing element than the Silverstat, a five-unit switch, of the type previously described and referred to as the "Beacon" unit, was used in conjunction with a resistor (Figs. 5 and 6). This meant that the range of the voltage supplied to the lamps was covered in five steps, rather than forty, which was considered satisfactory for brooding. The switches and resistor were connected in the control circuit so that as the switches opened, more resistance would be added to the circuit. Switches opened as the room temperature increased, thus more resistance was added and the current was decreased resulting in a lower degree of reactor core saturation. As the temperature in the room increased or decreased between 60 F and 80 F, the voltage supplied to the lamp load was regulated. Typical power demand curves for the Silverstat and stepping switch are shown in Fig. 7.

A variable resistor was placed in the control circuit so as to provide a simple means of lowering the level of maximum lamp output. As the birds grow older they require less brooding energy. Therefore, by means of this device, this could be accomplished without raising the lamps or changing the thermostat wafer adjustment.

This unit gave satisfactory results so far as brooding was concerned. From an economical point of view, its use will probably be limited to flocks of 5,000 to 10,000 birds and larger.

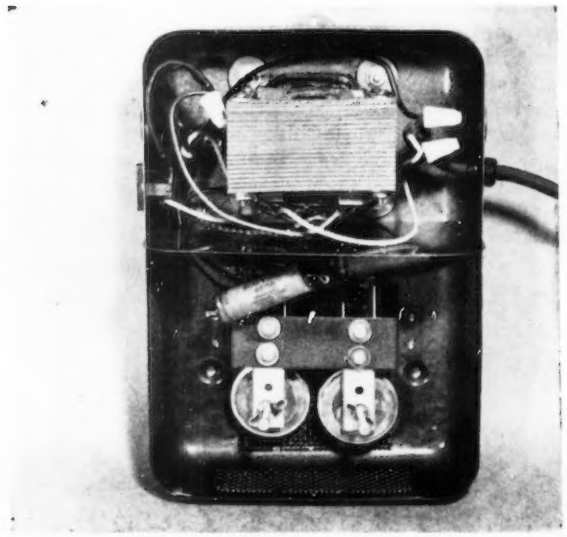


Fig. 8 Autotransformer control unit

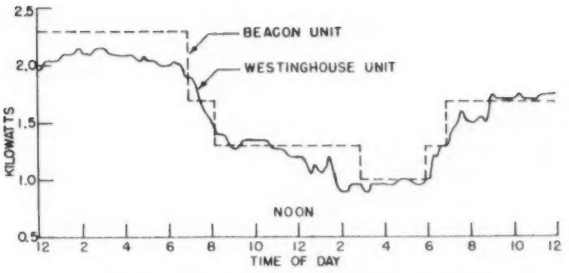


Fig. 7 Typical power demand for a 24-hr period

Autotransformer. In the spring of 1952 the Northern Signal Co. furnished a control employing an autotransformer to be tested (Figs. 8 and 9). This unit had a capacity of 1000 w. It was used on a brooder using four 250-w lamps.

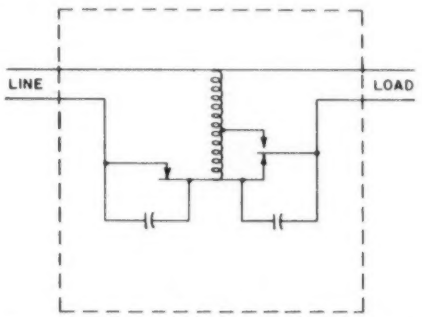


Fig. 9 Schematic drawing of autotransformer control

A gas-filled wafer was used to operate each of two snap-action switches. One switch was wired to taps on the transformer so that, with an increase in room temperature, the voltage to the lamps would be reduced to approximately one-half the line voltage. The other switch was connected in the circuit so that the entire unit would be de-energized with a greater increase in room temperature. Arrangements for an attraction light on this unit were not available, but the manufacturer is adding this feature. This was found desirable since the unit was tested during the summer. More steps in the range of control would probably be desired on this unit. This change is not contemplated.

With all of the units discussed, satisfactory brooding has been accomplished. The use of each has resulted in a substantial saving in electric energy from the amount that would have been consumed, had all lamps been fully energized at all times. The degree of saving depends on the factors that determine the energy demand. It is considered desirable during early stages of brooding, regardless of conditions in the brooder house that might reduce the brooder output, to furnish full energy output from all lamps. A switch in the circuit, to be operated manually, should be provided for this purpose.

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Procedure for the Design of a Farm Machine

Robert E. Stilwell

THE following is offered as a generally acceptable procedure for the birth of an agricultural machine. It should be borne in mind, however, that in certain instances the development of a product will not follow this procedure too closely. However, the general procedure is as follows:

A There must be the need for a machine, one that is probably less expensive, faster operating or more efficient than an existing process or machine.

B Generally the factory sales representative in a particular territory recognizes the need for the machine writes the general sales manager with pertinent information regarding the situation.

C At such time as he deems it advisable, the general sales manager will recommend this machine for discussion at a development meeting where future potential, economic advantages, development costs, and production possibilities can be thoroughly explored.

D Upon favorable acceptance by the development committee, the engineering department will draft a formal project application to be submitted for approval to the chief engineer, plant manager and possibly a development committee. A project application will generally consist of an estimated but detailed allocation of the appropriation requested by the engineering department for the complete development of the machine through to a production release.

E Upon signed acceptance of the project application, the design and development work will be assigned to an engineering group, which will proceed with the design, construction and test of a prototype machine to the satisfaction of the chief engineer, the management and the sales department.

G Following acceptance by these three departments, an engineering release will follow which will put this machine on a production basis.

This paper was presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at San Luis Obispo, Calif., February, 1953.

The author—ROBERT E. STILWELL—is a project engineer, John Bean Division, Food Machinery and Chemical Corp.

Design engineers at work on agricultural equipment

H Production tooling will then be made to produce the component parts of the machine just as economically as possible. This phase has a direct bearing on the quantity of production runs.

I Production of a specified number of machines would begin.

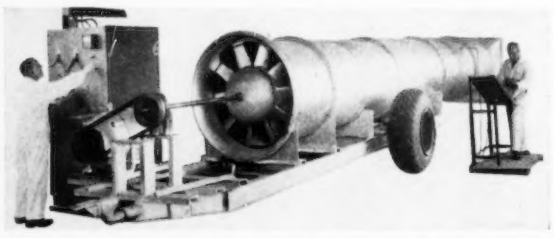
As an added point of interest it should be mentioned that it is sometimes difficult to economically justify the development and tooling cost of a certain machine to do a specific job, but in certain instances the situation may be handled from a somewhat different approach. One example of this is the possibility of developing a machine that is flexible enough to perform two or more similar jobs, thus amortizing the development and tooling expense over a greater number of applications than a single-purpose application could potentially justify.

With the foregoing background on the integration of engineering with management, sales and production, I will discuss the design problems that must be taken into consideration in bringing out a new machine. Problems of product designers vary considerably, depending upon the size of the company. They are, however, striving for high quality, low cost and reasonable profits for their design. Aside from problems which deal directly with company size, such as volume buying, automatic machinery, availability of laboratory equipment, personnel problems, and the like, there are a number of mutual problems common to all agricultural product designers, which are presented in the following outline:

1 *Analysis of the problem.* It is important for the designer to have in mind a satisfactory and desirable speed of operation, minimum efficiency requirements, care required in handling a product — and, if a factor, treatment of the problem by competitors, and any other such factors as may have a bearing on the design of the machine.

2 *Proper Analysis and Application of Engineering Fundamentals.* Generally most machines have some treatment of a technical nature regarding strength, deflections, chemistry, and the like. The designer must also call upon his background of experience to take whatever safe short cuts may be in order to control unnecessary development cost. An example of this would be the recognition that a certain size standard machine screw would hold adequately well without taking the time to stress this element. Short cuts of this kind are a definite economical advantage, however, they require a sound background of experience.

(Continued on page 758)



Engineers checking the efficiency and performance of a sprayer fan

Lethal Effect of Electrons on Insects Infesting Wheat and Flour — Part I

V. H. Baker, Oscar Taboada, and D. E. Wiant
MEMBER ASAE MEMBER ASAE

STORED grains, flour, and cereal products are subject to attack by insects which cause enormous losses annually. Cotton (1)* reports that at least $300,000,000 is lost annually in the United States as the result of insect damage to grain and cereal products. A few of the insects which attack wheat are able to bore into the sound kernel and deposit their eggs in the kernel. When the eggs hatch, the young larvae consume practically the entire kernel.

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and is authorized for publication as Journal Paper 1532 from the Michigan Agricultural Experiment Station. It reports on a portion of an investigation on the lethal effects of electromagnetic energy and subatomic particles on certain insects.

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Acknowledgments: The authors gratefully acknowledge the cooperation of O. R. Woods and N. A. Drake, physics department, The Upjohn Company, Kalamazoo, Mich., and of The Upjohn Company for the use of its Van de Graaff generator; also the cooperation of Dr. Margaret A. Ohlson, department head; Miss Mary L. Moor, assistant professor, and Miss Marcille Pridgeon, graduate assistant of the department of food and nutrition, Michigan State College, in conducting the baking tests.

*Numbers in parentheses refer to the appended references.

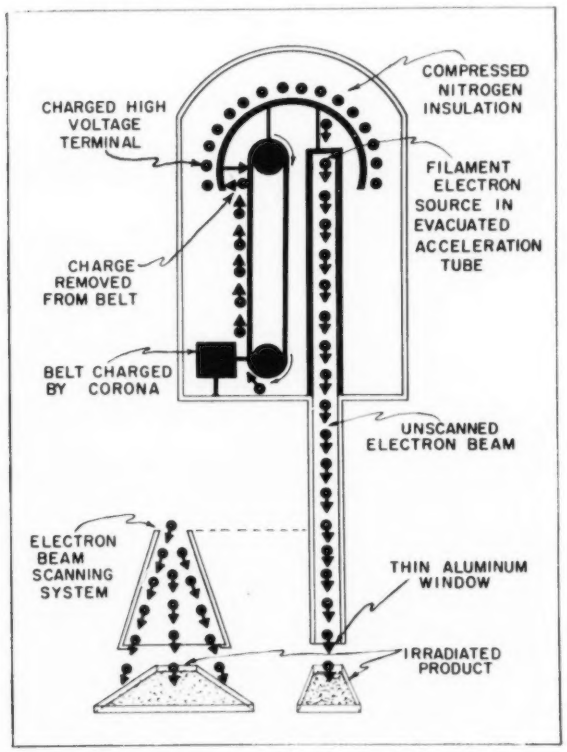

Fig. 1 Schematic sketch of the Van de Graaff electron accelerator with unscanned electron beam irradiating a product on a conveyor belt. A beam-scanning system may be installed in order to irradiate over a wider area

The granary weevil, *Sitophilus granarius* (*L*), is one of the most damaging insects to grain. The adult weevil lives on an average of 7½ months, each female laying between 300 and 400 eggs during this period. During warm weather the egg, larva, and pupal stages may be completed in less than 30 days. The flour beetle, *Tribolium confusum*, Duv, may be found in flour, prepared cereals and in grain. This insect is most commonly found in flour after it leaves the mill. The female may live for a year or more and lay 400 to 500 eggs. Under favorable conditions the development period from egg to adult may be as short as 30 days.

This paper is a report on part of the investigations being conducted by the agricultural engineering and entomology departments of Michigan State College in cooperation with the Upjohn Company of Kalamazoo, Mich. A brief discussion of electron treatment of the insects which infest wheat and flour, mentioned in the last paragraph, is presented.

Accelerated Electrons, Cathode Rays and Beta Particles. The terms accelerated electrons, cathode rays and beta particles are used interchangeably to designate the flow of electrons. The term beta particle is used to designate an electron emitted from an excited nucleus. In the past four years considerable progress has been made toward the development of high-voltage electron acceleration equipment which may be used for the so-called "cold" sterilization of foods and drugs. Trump, Van de Graaff, Burrill (2, 3, 4) and their associates were among the first to develop equipment for accelerating electrons. Dunn et al (5), Proctor and Goldblith (6, 7) and their associates were among the first investigators to treat various food products with accelerated electrons, and to study the effects on enzymes, microorganisms, molds, and spores. Yeomans reported on experiments using the capacitron treatment on various insects (8). Urbain (9) reported recently on facts about cold sterilization.

The Van de Graaff Accelerator. The Van de Graaff accelerator was used in the tests reported in this paper. A schematic diagram of the Van de Graaff generator is shown in Fig. 1. A corona discharge causes electrons to be deposited on a fast-moving belt. These electrons are delivered to the spherical shape high-voltage terminal. When the potential builds up to 2 million volts in the machine which was used, electrons from the heated filament in the evacuated acceleration tube are accelerated down through the acceleration tube through the thin aluminum window and into the product. As the electrons travel down through the acceleration tube they approach the speed of light. The Van de Graaff generator can be thought of literally as an electron gun shooting electron bullets into the product being irradiated.

Method of Testing. A series of ten tests have been conducted. The results of two tests are shown in Figs. 2 and 3. The samples for the granary weevil test were prepared by placing 50 adults in each of 25 9-cm petri dishes

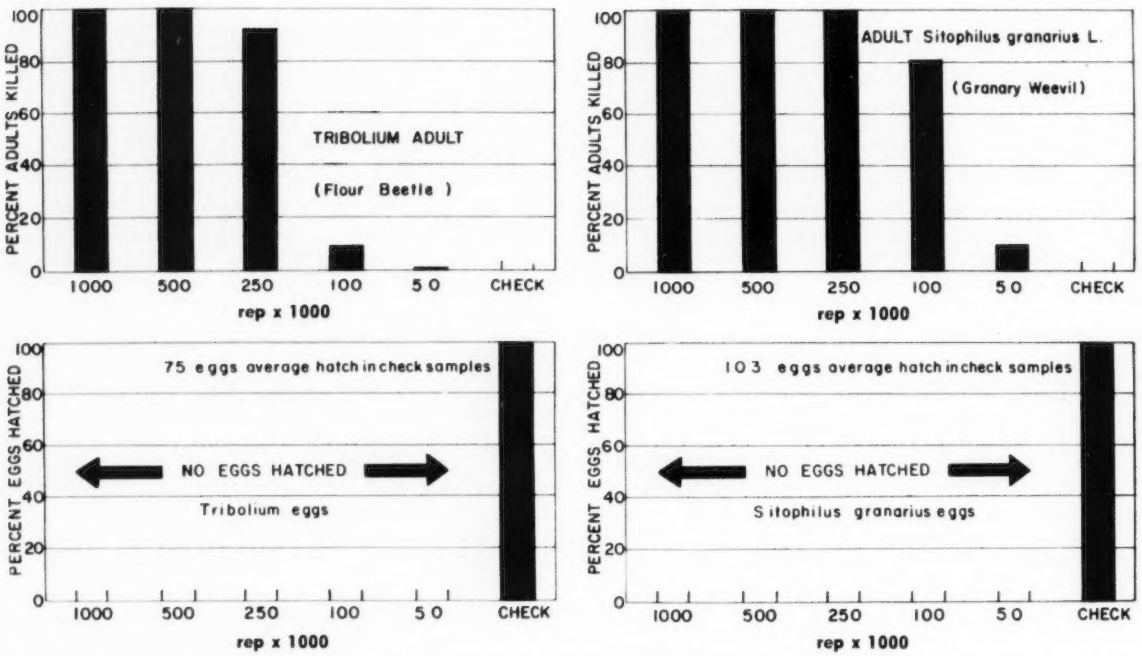

Fig. 2A *(Upper left)* Percent flour beetle adults killed one week after irradiated with various doses of 2-million-volt electrons • Fig. 2B *(Lower left)* Percent flour beetle eggs hatched after an incubation period of 43 days from day of irradiation with various doses of 2-million-volt electrons • Fig. 3A *(Upper right)* Percent granary weevil adults killed one week after being irradiated with various doses of 2-million-volt electrons • Fig. 3B *(Lower right)* Percent granary weevil eggs hatched after an incubation period of 43 days from day of irradiation with various doses of 2-million-volt electrons

containing 30 g of Cornell 595 wheat. The wheat had a moisture content of 10 percent wet basis and a density of 0.74 g per cc, and a specific gravity of 1.33. These samples were then placed in a constant temperature, constant humidity incubator (80F, 75 percent RH) for about three days before treatment, to allow sufficient time for the adults to oviposit. The samples were then treated with dosages of 2 million volt unscanned electrons as shown in Fig. 3. Five groups of four petri dishes containing a total of 200 adults in each group received dosages as shown in Fig. 3. The dosages were calculated according to the method suggested by Trump (2). Five petri dishes containing a total of 250 adults were used as check or control samples and were not treated.

The treated and untreated samples were observed for effects immediately after treatment, 24 hr after treatment, 48 hr after treatment, and one week after treatment.

The procedure for the treatment which gave the results shown in Fig. 2, using the *Tribolium confusum* flour beetle, differed slightly from the procedure listed above. Twelve samples each containing 100 adult beetles and 30 g of whole wheat were placed in 9-cm petri dishes and irradiated. A total of 5 dosages were used with two petri dishes containing a total of 200 adults receiving each dose. The remaining samples containing 200 adults each were used as controls and were not treated. The remainder of the procedure was essentially the same as that listed for the granary weevil.

Germination tests were made on wheat which received various dosages of accelerated electrons. Preliminary baking tests were conducted on approximately 38 lb of irradiated whole wheat flour with a dose of 5×10^5 rep and on approximately 38 lb of flour made from Cornell 595 wheat irradiated with a dose of 5×10^5 rep.

Units of Radiation or Dosage. The accelerated electron dosage falling upon an absorber can be calculated with accuracy. The dose delivered to materials on a moving belt may be derived more simply by direct comparison with the

Fig. 4A *(Top)* Wheat artificially infested with granary weevils and irradiated with an accelerated electron dose of 100,000 rep from the 2-million-volt Van de Graaff generator. Picture taken after an incubation period of 43 days from date of treatment • Fig. 4B *(Bottom)* Wheat artificially infested with granary weevils used as a check sample (untreated). Picture taken after an incubation period of 43 days from date of test

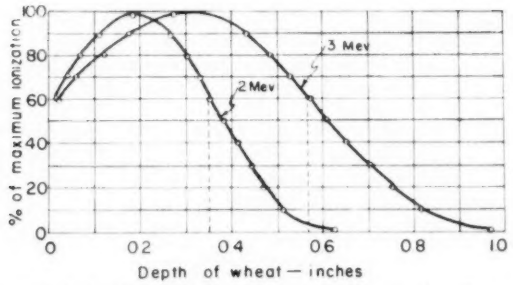

Fig. 5 Calculated depth of penetration of a beam of 2-million-volt electrons in wheat and flour with a density of 0.74 g per cc with 60 percent of maximum ionization at top and bottom of sample

chemical effects of accelerated electrons as determined on stationary samples.

Accelerated electron dose may be specified in rep (roentgens equivalent physical) for biological studies, whereas the same dose is expressed in ergs and joules for physical studies. One rep represents a very minute quantity of energy.

The conversion factors for these units are:

1 rep = 83.8 ergs per gram of air, or
93 ergs per gram of water or tissue

10^6 rep = 9.3 joules per gram of water

1 joule = 10^7 ergs = 1 watt-second = 2.78×10^{-7} kwh
= 0.24 calories

1 mev = energy acquired by one electron when accelerated through a potential of one million volts.

RESULTS AND DISCUSSION

The results of two tests using 2-million-volt electrons on the granary weevil and flour beetle are shown in Figs. 2 and 3. The dosage in rep was calculated by using a density of 0.74 gr per cc for wheat and flour. A dose of 5×10^5 rep was lethal to the granary weevil immediately after treatment, but not lethal to 100 percent of the flour beetles. The data in Figs. 2A and 3A indicate that a dose of 2.5×10^5 rep was lethal to 92 percent of the adult flour beetles one week after treatment, and a dose of 1×10^5 rep was lethal to 82 percent of the granary weevils one week after treatment (see Figs. 4A and 4B).

The charts (Figs. 2B and 3B) show that a dose of 50,000 rep will sterilize the granary weevil and flour beetle eggs. Data from other tests conducted (10,11) show that a dose of 10,000 rep will sterilize the granary weevil and flour beetle eggs. Eggs laid by the adult insects tested did not hatch when the adults were irradiated with 10,000 rep before ovipositing. A dose of 0.75×10^5 was lethal to 100 percent of flour beetle larvae two weeks after treatment. It was also found that a dose of 1×10^5 rep was lethal to 97 percent of adult granary weevils one week after the adults were irradiated in plain petri dishes with no grain. A dose of 0.75×10^5 was lethal to 100 percent of adult flour beetles one week after the adults were irradiated in plain petri dishes with no flour. The dosages were based on an insect density of one.

Fig. 6 *(Left)* Bread baked from 75 percent treated whole wheat flour and 25 percent plain white flour. The treated whole wheat flour was ground from wheat irradiated with a dose of 5×10^5 rep. *(Right)* Bread baked from 75 percent untreated whole wheat flour and 25 percent plain white flour

Penetration of Accelerated Electrons into Wheat and Flour. In order for electrons to be effective in ionizing tissue and thus cause lethal effects, the energy of the electron must be absorbed by a material as the electron travels through the material. The actual penetration depths of accelerated electrons into a material is of little value unless some information is available on how the energy is dissipated in the material. The percent of maximum ionization curves for wheat and flour (Fig. 5) was calculated from published ionization curves of aluminum, using a density of wheat and flour as 0.74 g per cc (11).

If wheat or flour is irradiated on a conveyor belt and 60 percent of maximum ionization is to be obtained in the top layer of flour and in the layer of flour next to the conveyor belt, then the maximum depth which can be treated is about 0.35 in for 2 mev electrons, and about 0.57 in for 3 mev electrons. These depths may be more than doubled when the material is irradiated from top and bottom. Calculations show that a depth of about 1.0 in of wheat or flour can be treated if irradiated from the top only with 5 mev electrons, or a depth of more than 2.0 in can be treated if irradiated from the top and bottom with 5 mev electrons. That is assuming 60 percent of maximum ionization in the top and bottom layers.

Germination Tests. Tests conducted indicate that germination may not be a criteria for determining the effects of accelerated electrons on wheat. The majority of the samples tested with doses as shown in Fig. 2A germinated; however, no emergence was obtained when the seed receiving a dose of 1×10^5 rep or above were planted. Seed receiving 1×10^4 rep were definitely retarded in growth as compared to untreated seed growth two weeks after emergence.

Baking Tests. Preliminary baking tests were conducted using about 38 lb of whole wheat flour irradiated with 5×10^5 rep and about 38 lb of whole wheat flour made from irradiated Cornell 595 wheat receiving a treatment of 5×10^5 rep. The treated flour was baked into a 100 percent whole wheat loaf. The flour from the treated wheat was more nearly the consistency of a meal and required some white flour for satisfactory fermentation. This was not caused by the electron treatment but was a result of the grinding process. Both products produced a satisfactory loaf of bread though there appeared to be some effect on tenderness, flavor and moistness in the bread from treated flour or grain. Further baking tests are planned.

SUMMARY AND CONCLUSIONS

This paper contains a brief report on the lethal effects of accelerated electrons on the flour beetle and granary weevil with a discussion of the germination of treated wheat and preliminary baking tests made from treated flour. The following conclusions and statements merit consideration:

1 The biological and chemical effects of accelerated

electrons are the same as those of X rays and gamma rays. No induced radioactivity is produced in the product at voltages below 21 million volts. The rise in temperature of a product when irradiated with a dose of accelerated electrons is negligible when compared with the heat method of sterilization. A dose of 100,000 rep will raise the temperature of wheat or flour about one-half degree Centigrade.

2 The penetration of accelerated electrons into matter is less than that of X rays of corresponding voltages, but their penetration is of sufficient magnitude to be considered. The maximum penetration of 2 million volt electrons into wheat and flour, with a density of 0.74 g per cc, with the bottom and top of the layer receiving 60 percent of maximum ionization is about 0.35 in or about one inch when irradiated from top and bottom. The penetration of electrons into wheat and flour may be increased by increasing the accelerating voltage.

3 The electron dose can be metered, thereby providing a continuous record of an uninterrupted flow of product on a conveyor belt beneath the electron beam.

4 An electron dose of 10,000 rep will sterilize flour beetle and granary weevil eggs, and this same dose will prevent the adults from reproducing.

5 A dose of 5.0×10^5 rep was lethal to 100 percent of adult flour beetles immediately after treatment, whereas a dose of 2.5×10^5 rep was lethal to 100 percent of adult granary weevils immediately after treatment. A dose of 2.5×10^5 rep was lethal to 92 percent of adult flour beetles one week after treatment and a dose of 1×10^5 rep was lethal to 82 percent of adult granary weevils one week after treatment.

6 A dose of 10,000 rep was detrimental to wheat seed. Seed treated with doses above 1×10^5 rep germinated but did not emerge and grow.

7 Preliminary baking tests made from flour and wheat receiving a dose of 5×10^5 rep indicate that a satisfactory loaf of whole wheat bread may be produced from treated flour. A taste panel did detect a slight change in bread made from the treated flour; however, this change in taste was not necessarily undesirable. Since the dose of 5×10^5 rep is more than necessary for insect control, further tests are planned with reduced dosages.

8 According to Proctor and Goldblith (6), cathode rays or accelerated electrons present interesting possibilities, although the installation and maintenance costs involved may limit the extent of such usage. Color and flavor changes may vary greatly with the product treated, but means of minimizing certain of these undesirable changes have been found.

9 More research is in progress in order to study further the effect of accelerated electrons on various food products including the effects on the baking, nutritional, and keeping qualities of irradiated flour and grain. Further information will be reported in Part II of this paper.

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Design of a Farm Machine

(Continued from page 754)

3 *Proper Selection of Materials and Manufacturing Processes.* This one particular phase of design is the touch of competition that has given American industry its international greatness. From a manufacturing standpoint, there are generally many ways to construct a machine element; however, certain manufacturing processes, depending upon production volume, will lend themselves economically better than others. From a material standpoint, let me cite the alternative of building a farm plow out of mild steel and structural steel elements which in time will rust, or making the plow out of stainless steel elements which won't rust, but cost in the neighborhood of 200 to 300 percent more, thereby probably price the implement right out of the competitive market.

4 *Judgment of Indeterminate Problems.* This phase treats of such factors as wear, corrosion, friction and unusually loaded irregular shapes. Certain design problems do not afford formal solutions and a broad background of experience and a sound evaluation of the application will dictate a decision.

As a common illustration, generally in moving parts, and especially in agricultural products, wear always presents a problem, and some decision must be made as to wear life.

5 *Application of Psychological Factors Involving Appearance, Habit and Fear.* A particular machine may be functionally sound with an acceptable efficiency, however, due to its overall appearance there may develop a strong sales resistance to it. For example, although the emphasis today is on streamlining, the public will only accept a gradually changing trend, and there should be some caution taken in not changing appearances too fast. Another example is the case of valve shutoffs, which rotate clockwise to close and counterclockwise to open. It would be generally a poor approach to design a valve that would change this habit of operation. Fear of machinery is generally built up by noise, and any loud noises should be dampened.

6 *Design for Patent Coverage.* Every effort should be taken to protect the time and expense that has gone into the design of the machine.

Flow Patterns of Air Through Grain During Drying

Tappan Collins

WHEN our company introduced its Quonset 16 grain dryer (Fig. 1) in the summer of 1952, the first units manufactured were dedicated to research, the purpose of which was to obtain fundamental information useful in the design and farm operation of these aeration drying units.

From the beginning it was recognized that one of the most important and least clearly defined factors in the design of any grain dryer is that of equitable distribution of the available air throughout all parts of the mass of grain. Unless this factor could be measured and understood, there would be little more than the customary conjecture that all of the grain would be dried, or dried to reasonably uniform moisture content throughout, or in minimum elapsed time. In short, some forthright evaluation of this factor should by all means be sought to provide an intelligible, measured understanding that would permit the distribution of available aeration to be influenced as effectively as possible by our design.

On this fundamental problem of air distribution we have been unable to uncover, in all the published literature, a single item referring to any actually measured flow net in any full-scale grain-drying operation. In the summer of 1952 a general scheme of attack on this problem was devised by W. V. Hukill and C. K. Shedd of the USDA grain storage research staff stationed at Ames, Iowa. Our company arranged for the installation of two Quonset 16 grain dryers at the Iowa State College agricultural engineering experimental farm at Ames. A little later, three additional test units were installed at widely separated experiment stations — one each at State College, Pa.; Stuttgart, Ark., and Beaumont, Tex. In these test units, the techniques originating at Ames were modified or elaborated or replaced as deemed advisable at Pennsylvania State College, or the University of Arkansas, or the A. and M. College of Texas.

With respect to distribution, this is a problem of fluid flow through a porous medium, and its treatment proceeds by study of successive or typical plane sections through the problem. For the Quonset 16 grain dryer, the section of dominant interest is the transverse section taken at mid-length of the storage, for nearly the whole mass is represented by sections differing in degree only from this section.

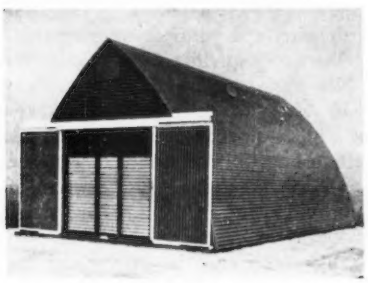
This transverse section of the Quonset 16, original 1952 design, is shown in Fig. 2. Air is exhausted into an axially disposed plenum chamber of 5.5 sq ft cross-sectional area, and 6 lin ft transverse perimeter. The grain mass is 103.5 sq ft in cross-sectional area, with an exposed (top) surface about 10 lin ft wide and with a half-inch-wide vent in each side wall 2 ft above the floor level.

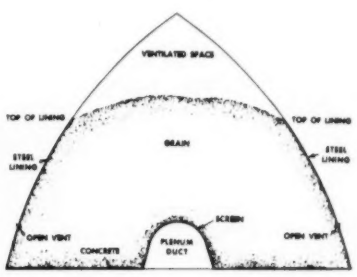
At intervals during the operation of each test, three factors were measured for identified points in this transverse section, and in other locations. Temperature was read at enough locations to permit isotherms to be plotted over the section (Fig. 3). Probe samples were secured and enough determinations of percent moisture content were made to permit contours of equal moisture content to be drawn for the section (Fig. 4).

In addition to these conventional temperature and moisture patterns, the flow net for the section was developed from field data. This repeated development of the measured flow net over a cross section through a mass of actual grain in course of a full-scale aeration drying operation still

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Pittsburgh, Pa., June, 1953, as a contribution of the Farm Structures Division.

The author — TAPPAN COLLINS — is research engineer, Stran-Steel Division, Great Lakes Steel Corp.





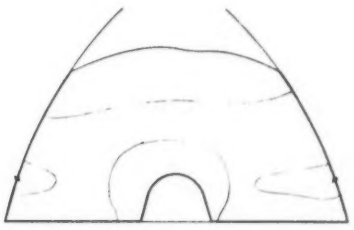
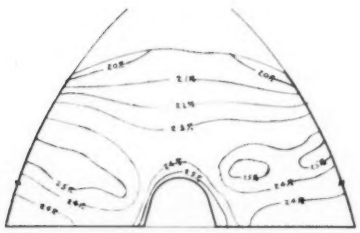
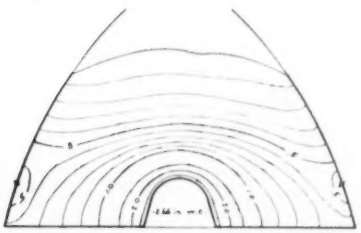


Fig. 1 *(Left)* A Quonset 16 grain dryer • Fig. 2 *(Center)* Transverse section of Quonset 16 grain dryer • Fig. 3 *(Right)* Isotherms plotted over section of grain dryer





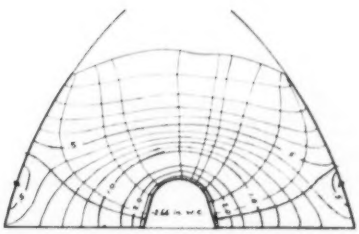


Fig. 4 *(Left)* Contour lines of equal moisture content • Fig. 5 *(Center)* Contours of equal static pressure, or equipotentials. Fig. 6 *(Right)* Lines defining direction of flow drawn directly on the pattern of equipotentials

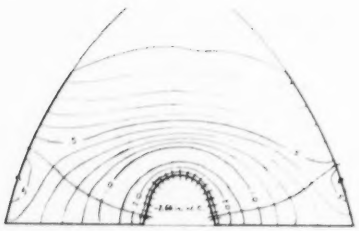
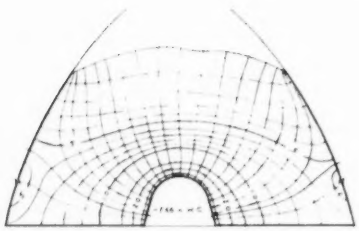
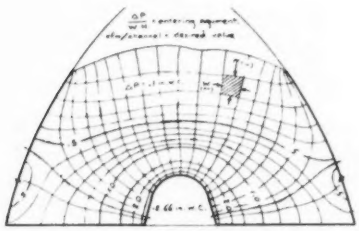




Fig. 7 *(Left)* Spacing of flow lines in the dryer section • Fig. 8 *(Center)* Net of flow lines radiating outward from points established on perimeter of plenum duct • Fig. 9 *(Right)* Calibration of the flow net

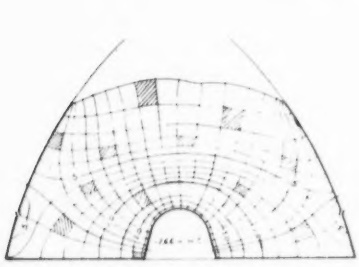
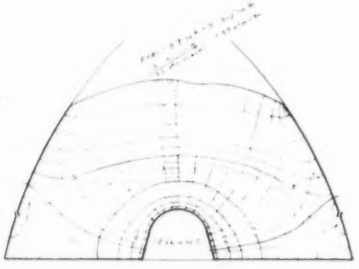
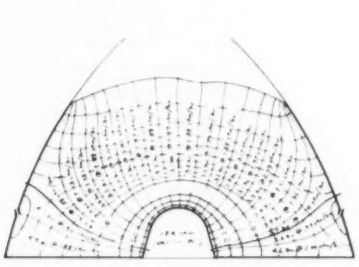




Fig. 10 *(Left)* Average calibration of flow net • Fig. 11 *(Center)* Determination of cubic feet per minute per bushel for one channel • Fig. 12 *(Right)* Determination of cubic feet per minute per bushel per channel

presents a formidable challenge. By means of small-diameter metal tubing supported on trellis work so that the tube ends were positioned at identified locations in the cross section under study, the static pressure at identified points in the cross section was measured on a manometer. Contours of equal static pressure, or equipotentials, were developed and plotted from these readings (Fig. 5).

Lines defining the direction of flow were drawn directly on the pattern of equipotentials (Fig. 6), the only geometric requirement being that these flow lines must be normal to the equipotentials. The resulting flow net would be of severely limited value in appraising a design if the spacing between flow lines was random and without dimensional significance. If any region of the cross section traversed by all flow lines in the section can be identified as having, for all channels, equal pressure gradient, equal moisture content and equal degree of compaction, then the flow lines may be equispaced where they cross such a region and the flow lines will then define channels carrying equal volumes of air per channel.

For these tests the region immediately adjacent to the perimeter of the plenum duct appeared to fulfill substantially the requirements of equality of pressure gradient, equality of moisture content and equality of degree of compaction (Fig. 7). For tests involving fans exhausting into the plenum duct this region at the perimeter of the plenum duct should be, of all regions, most stable in its moisture content and degree of compaction, because it should be last to respond to aeration drying, and the substantial equality of pressure gradient could be confirmed for these tests with each set of static-pressure readings. For these reasons flow lines were started on the cross section by marking off the perimeter of the plenum duct into 20 equal spaces and flow lines were drawn radiating outward from the points thus established on the perimeter of the plenum duct (Fig. 8).

The volume of air represented by each channel between flow lines, assuming one foot thickness for the cross section, can be evaluated for any location in the section by noting the percent of moisture content at that point at that time, estimating the degree of compaction, and measuring the pressure gradient as defined by the equipotentials (Fig. 9). These data constitute necessary and sufficient entering argument to the pertinent literature, specifically C. K. Shedd's paper entitled "Some New Data on Resistance of Grains to Air Flow", published in AGRICULTURAL ENGINEERING for September, 1951. The air flow, in cubic feet per minute per square foot of cross-sectional area of channel, as determined from this published reference, multiplied by the width of channel as scaled from the drawing of the flow net, yields a value of the volume of flow represented between two adjacent flow lines. This value must be determined for several locations sampling all regions of the whole cross section, and these several values averaged to obtain a sound evaluation of flow net scale (Fig. 10). The separately determined values may vary widely. However, a real flow net has the property of smooth unbroken continuity, and is not an assortment of discrete contradictions, so that abruptly varying separate determinations mean only that inaccuracies are involved. The influence of these should be minimized by averaging several separate determinations.

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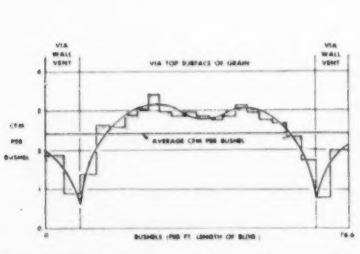

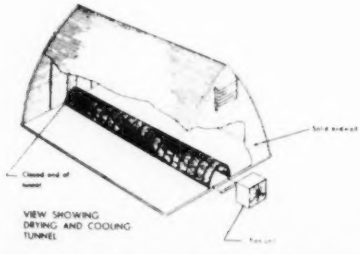

Fig. 13 *(Left)* Diagram of distribution of air • Fig. 14 *(Right)* View showing drying and cooling tunnel

Supplemental Irrigation on Sandy Soils in Michigan

E. H. Kidder and J. R. Davis
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THE early settler in Michigan was probably little concerned about irrigation. He was initially confined in his agriculture to the higher, naturally drained soils, because the more productive bottom land lacking drainage was either swamp or just too wet to farm. It was this condition that in 1822 led the commander of the garrison at Saginaw to prematurely conclude that "nothing but Indians, muskrats, and bullfrogs could live here." However, after Congress passed the "Swamp Act," the open ditch and tile drainage that followed liberated approximately 10 million acres of highly productive soil in Michigan.

Drainage, however, was only one phase of the water-management problem. A second type of water adjustment was needed to meet the demands of shallow-rooted crops grown on sandy soils in years of inadequate rainfall. Supplemental irrigation by providing needed water has eliminated one of the limiting variables in crop production.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Pittsburgh, Pa., June, 1953, as a contribution of the Soil and Water Division. The studies reported are being conducted as cooperative projects between the departments of agricultural engineering, horticulture and farm crops, Michigan Agricultural Experiment Station. The paper is authorized for publication as Journal Paper 1521 of the Michigan station.

The authors—E. H. KIDDER and J. R. DAVIS—are, respectively, associate professor and instructor, agricultural engineering department, Michigan State College.

Acknowledgment: The authors express their appreciation to R. L. Carolus, R. F. Carlson, Milo Tesar, Ernest Wheeler, Raleigh Barlowe, Paul Schleusener and others who assisted in conducting these studies, and to Michigan Orchard Supply Company, National Rain Bird Sales & Engineering Corporation, and the Aluminum Company of America for their cooperation in furnishing equipment used in the truck crop studies.

In Michican, the combination of climate and soils, together with the vast, ready markets of Detroit, Chicago, South Bend, Grand Rapids and Flint, has resulted in large dividends to those who have had a keen appreciation of the irrigation potential. At present it is estimated that 1600 systems are used to irrigate 60,000 acres.

It is the purpose of this paper to describe the conditions throughout the state that brought about the present irrigation development and to present the results of irrigation research.

CLIMATE OF MICHIGAN

Two distinct types of climate are observed in Michigan (1)* due to the effect of the surrounding Great Lakes. The interior climate of both the upper and lower peninsulas alternates between continental and semimarine with changing meteorological conditions. The equalizing or tempering influence of the Great Lakes results in a modified marine climate along the shores of Lakes Superior, Michigan, and Huron, and produces a more equable climate throughout the entire state.

The normal pattern of solar radiation received at East Lansing (2) falls below the mean for all other United States stations. Atmospheric water vapor and industrial pollution have a marked effect on the radiation received in Michigan. A comparison of average daily total solar radiation at East Lansing with other U.S. stations shows that East Lansing receives radiation comparable to Pittsburgh, New York, Chicago and Boston, where industrial atmospheric pollution affects the radiation received.

*Numbers in parentheses refer to the appended references.

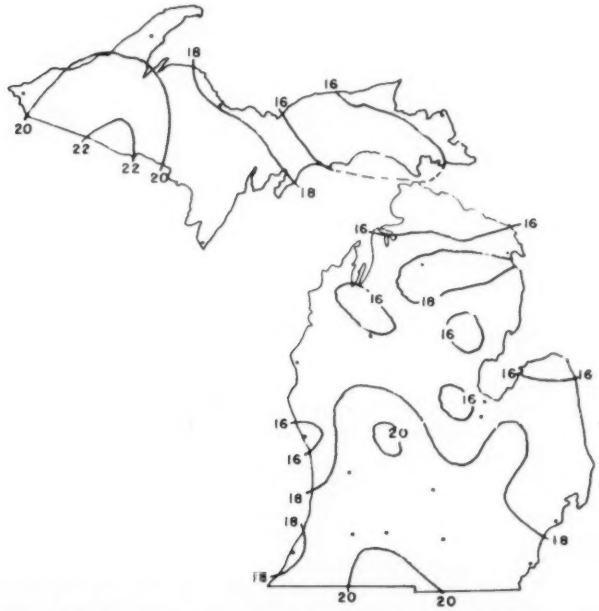

Fig. 1 Average warm-season precipitation in inches, April through September

Fig. 2 Frequency of July droughts of 21 to 28 days duration based on probable occurrence in a ten-year period

In the lower peninsula of Michigan, the average annual precipitation varies between 26 and 36 in. The average precipitation during the months of April through September ranges between 16 and 20 in. (Fig. 1).

The time of occurrence and the quantity of precipitation received during the latter part of the crop-growing season can be quite critical. The month of July is one of these critical months, because moisture reserves in the soil may be seriously depleted by this time. During this month, the average precipitation ranges between 2¼ to 3½ in over the lower peninsula, with the greater part of the area receiving only 2½ to 3 in. This amount of precipitation would balance an evapotranspiration rate of only 0.08 to 0.1 in per day, which is roughly one-third to one-half of the daily requirement of many crops. Thunderstorm activity is responsible for most of the summer season precipitation, and since thunderstorms usually give intense precipitation to small areas, the quantities of water received and the frequency of distribution is erratic over the entire state. Dry periods develop in parts of the state even during the growing seasons of record wet years. Yearly or even monthly averages, however, do not have too much significance, in that a dry period of even a few days can be serious to a grower of shallow-rooted crops on sandy loams and sands.

In order to evaluate the drought expectancies in the state, an analysis was made of the precipitation records of 36 long-term stations in the lower peninsula to determine the frequency of occurrence of droughts† of 7 to 14, 14 to 21, 21 to 28, 28 to 35, 35+ days during the months of May through September (3). Twenty-five drought-frequency maps were prepared for the lower peninsula; in addition, bar graphs showing the total number of droughts recorded for each drought period for each station were also constructed.

The map in Fig. 2 is one of the series of 25 charts. This gives the frequency of 21 to 28-day droughts in July. It shows specifically on the basis of frequency which areas of the state are likely to be more deficient in rainfall in July. The western edge of the state can expect droughts of 3 to 4 weeks duration to occur twice in a 10-yr period. The eastern shore of the state north of Detroit can expect one drought of this duration in each 10-yr period. The data for each station also is adaptable to the construction of charts like Fig. 3 to compare the frequency of droughts at specific locations in the state. South Haven is in the truck and fruit producing area on the edge of Lake Michigan in the southwest part of the state; Ypsilanti is in the truck area surrounding Detroit. Droughts of 21 to 28 and 28 to 35 days duration were more common at South Haven in July and August than at Ypsilanti. The longer period droughts are also more frequent in July and August than in May, June and September. These drought frequency maps and graphs, when used in conjunction with soil and crops information, enable agricultural workers to determine more quantitively the potential need for supplemental irrigation.

†A drought is defined as a period constituting seven or more days in which less than 0.25 in of precipitation have occurred in 24 hr.

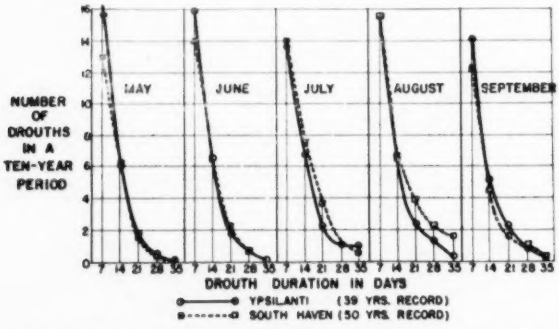

Fig. 3 Frequency of drought based on probable occurrence in a ten-year period

SOILS OF MICHIGAN

The glaciers that advanced and retreated over Michigan left nearly 250 different soil series. While the agricultural engineer doing irrigation design is not primarily concerned with soil classification, he cannot do a satisfactory design job unless he has definite information on the capillary water-holding capacity and infiltration rates for each soil. The coarse-textured soils such as the sands and loamy sands that predominate over most of the western two-thirds of the lower peninsula generally have low capillary water-holding capacities and hence have a greater need for supplemental water than the lake bed plains loams to clay loam soils of the Saginaw Valley, the "thumb area" and the tier of counties along the east edge of the state below "the thumb." It is estimated that there are in the state 9 to 10 million acres of sandy and light sandy loam soils, 12 to 13 million acres of sandy loam and loams, 10 to 11 million acres of silt loams and clay loams and about 5 million acres of organic soils (4).

The areas that are most intensively irrigated are found in the tier of counties along the shore of Lake Michigan, scattered tracts in the counties near Detroit, and scattered areas of potatoes, pastures and vegetable crops throughout the lower peninsula. These regions of irrigation are located on either sandy, sandy loam or organic soils, and with high-return vegetable, small fruit and potato crops, the economic benefits of applying supplemental water are the greatest. Because the number of distinct soil types is so great and the associations of these soil types so complex, no one type of farming predominates nor can one set of irrigation recommendations suffice for all areas.

Similar soils have been grouped; tentative irrigation recommendations for each group and crop, based on available information and liberally seasoned with judgment, are being developed.

IRRIGATION OF TRUCK CROPS

The drought of the early thirties created a great deal of

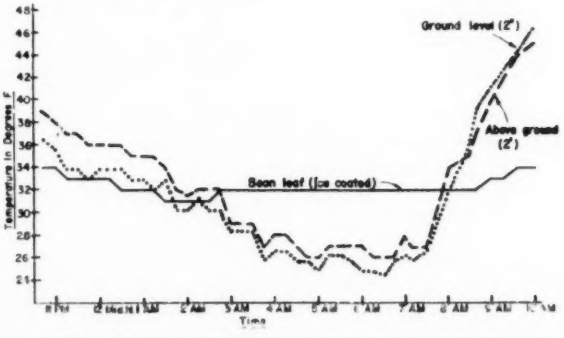

Fig. 4 The effect of continuous water application on air and ice-coat temperature. (Frost of October 25 and 26, 1950)

interest in and a demand for information on irrigation. It was during this period that Robey (5) developed the porous-hose method of irrigation and ingenious growers made their own sprinklers to use with boiler tube and available pipe and pumping units. Irrigation studies were carried out on potatoes during this period by Robey and Amundson at the Lake City Experiment Station in 1931-33 (6). The Irish Cobbler variety grown on irrigated plots outyielded that grown on nonirrigated plots by an average of 71 bu of U.S. Grade No. 1 per acre. The results of irrigation were even more favorable with the Russet Rural variety. When grown on the irrigated plots, this variety produced an average of 100 bu of U.S. Grade No. 1 per acre more than was grown on the non-irrigated plots.

A second major upsurge in interest in irrigation took place in the late forties largely because of dry weather, favorable farm income and the introduction of light-weight, portable pipe. It was this upsurge that resulted in the establishment of a vegetable crop irrigation study at East Lansing in 1948.

This irrigation study was established to determine the physical and economic aspects of truck crop irrigation. The site selected was on a Hillsdale sandy loam soil which is typical of the textural classification found on over 7 million acres in Michigan. Rainfall data were collected throughout the growing season from U.S. Weather Bureau standard rain gages located on the plots. These data are compared with the Lansing-East Lansing Weather Bureau long-time average in Table 1. Because the rainfall during this five-year period fluctuated decidedly on both the dry and extreme wet sides of normal, the data represent a good sample of the variation in precipitation that can be expected from month to month and seasonally. The year 1948 was an exceptionally good irrigation year in that the total rainfall for the measured period (May 15 to September 15) was 9.28 in, which is 74 percent of the normal 12.6 in. (Table 1) (7).

TABLE 1. RAINFALL ON IRRIGATION PLOTS
(In inches)

	1948	1949	1950	1951	1952
May 15 to 30	0.66	1.91	1.20	1.75	3.69
June	3.94	6.74	4.73	2.66	1.30
July	1.91	2.68	7.10	1.86	1.78
August	1.00	4.21	3.50	2.93	3.24
September 1 to 15	1.77	1.41	3.99	1.33	1.22
Total	9.28	16.95	20.52	10.53	11.23
Percent of normal rainfall	74	135	163	84	89

The July rainfall was 1.91 in and in August only 1.00 in of rain fell. This sequence of dry months resulted in an extreme depletion of moisture in the root zone of tomatoes and sweet corn by late August.

The year 1949 was not a good irrigation year; the seasonal rainfall of 16.95 in was 135 percent of normal and the dry period that developed in late August and early September did not appear to appreciably affect yield (8).

In 1950, the study was moved to the horticulture department farm where the soil is also Hillsdale sandy loam. The site designated for the study in 1950 included a slope and depressional area. The rainfall during the period of record was 20.52 in, which is 163 percent of normal (Table 1). Appreciable surface runoff occurred on the sloping area with the result that the lower plots were flooded several times and the data thus made unreliable. This flooding depressed the yields on the flooded plots.

The year 1951 was a record wet year for the state, but not so at East Lansing, where the crop season total averaged 10.53 in, or 84 percent of normal. The return of a general drier than normal year in 1952 created a considerable upsurge in irrigation interest. It was not a critically dry crop season at East Lansing with the rainfall of 11.23 in representing 89 percent of normal.

Several criteria of when to irrigate were tested during the 1948 and 1949 season:

1 Plaster of paris blocks — Restore to field capacity when 50 percent of available water has been withdrawn.

2 One inch per week — Apply 1 in of water if rainfall in the past week has not totalled 1 in.

3 One and one-half inches per week — Apply 1.5 in of water if rainfall in the past week has not totalled 1.5 in.

4. Two inches each two weeks — Apply 2 in of water if rainfall in the past two weeks has not totalled 2 in.

The last two methods were considered to be unreliable and wasteful "rules of thumb" and their use was discontinued in 1950.

In the studies carried on in 1951-52, moisture blocks were buried at 5, 10, and 15-in depths and read with the Bouyoucos moisture meter. Replicate plots were established to be irrigated and restored to field capacity when (1) 50 percent of the available water in the root zone had been removed, and (2) 75 percent of the available water was removed.

A third replicate was irrigated according to the criteria of adding one inch if the previous week's rainfall was less than one inch. A fourth replicate was unirrigated. Six crops (sweet corn, tomatoes, beans, cabbage, cauliflower and broccoli) were irrigated in 1951. Sweet corn, cabbage and cauliflower did not respond to irrigation that year. The best irrigation treatment in 1951 was to add water in sufficient quantity to restore the soil to field capacity when 50 percent of the available water had been removed. A 25-percent increase in the yield of tomatoes, a 23-percent increase in the yield of lima beans and a 10-percent increase in the yield of broccoli resulted from this irrigation practice. The rate of fertilizer application on all plots was 800 lb of 3-12-12 per acre (Table 2).

TABLE 2. RELATION OF YIELD INCREASE DUE TO IRRIGATION TO NORMAL RAINFALL

	1948	1949	1950*	1951	1952
Yield, tons per acre†	25.0	21.0	—	16.8	17.0
Percent of normal rainfall	74	135	163	84	89
Yield increase over non-irrigated tons per acre	10	2.2	—	3.4	3.6

*Plots in low areas were flooded.
†Most responsive irrigation practice.

In 1952, the study was altered to include only tomatoes. The criteria of when to irrigate were the same as in 1951, except that a calculated method of water depletion adapted from Thornthwaite's (9) potential evapotranspiration data was substituted for the one inch per week rule of thumb. The greatest yield increase of 26 percent was obtained on the plots that were irrigated when moisture block measurement indicated that 50 percent of the available water had been removed. The second highest yield increase of 20 percent occurred on the plots that were irrigated when it was *calculated* that 50 percent of the available water had been removed. The lowest increase, 14 percent, was obtain-

ed on the plots that were restored to field capacity when 75 percent of the available water had been removed. The yield on the check plot averaged 16 tons per acre. All plots were fertilized with 800 lb per acre of 3-12-12 (Table 2).

FROST CONTROL

Truck crop and fruit growers are annually faced with the possible loss of a part of their crop by late spring and early fall frosts. On the average, the last killing frost in the spring can be expected in the southern part of the lower peninsula between April 25 and May 10. The date of the first killing frost in the fall is usually between October 5 and 20.

Plants vary greatly in their resistance to frost. The thin-leafed plants as well as young blossoms are particularly sensitive to frost injury. Strawberry growers in particular have made extensive use of their irrigation systems in Michigan to protect the strawberry blossoms.

The frost problem is also of concern to the grower on organic soils. Many of these areas are so low in elevation and lose their heat so rapidly on a still, clear night that frost may occur during the summer months.

The meteorological condition most conducive to a radiation-type frost is a cold air mass moving into the area behind a cold front; then if the air becomes essentially calm by early evening and the sky clears, conditions are ideal for the development of a temperature inversion and rapid cooling of the air near the ground surface. These temperature inversions are commonly quite intense within a few feet of the ground surface.

The major portion of the information collected on frost prevention by irrigation has come from growers using sprinkler irrigation systems. A severe late spring frost occured in southwest Michigan in 1949, during which growers reported protection of strawberry blossoms against temperatures as low as 22F. Those growers who used irrigation that year have been enthusiastic about the results. One grower's expression was that it was the difference between an 80 percent crop and a 20 percent crop. Many other growers now feel that frost protection is just as important as drought protection.

Howe (10), in discussing work on peat in Minnesota, reported successful protection of truck crops against a 26-deg frost.

Michigan growers have found that repeat applications of water for frost protection several times within one week have produced a waterlogged condition of the soil that resulted in a retardation of plant growth. It can be appreciated that, if ½ in per hr is applied from 6 to 8 hrs per night for two to three nights in a week, the soil has received sufficient water to saturate it to a considerable depth, if it was at or near field capacity when the application started.

It was this excess water problem that prompted the initiation of a study in the spring of 1950 to determine how low a rate of application was needed to give effective protection.

A single low-angle, low-capacity rotary irrigation sprinkler was placed in the center of a test circle. Potted strawberry plants were placed at intervals along radii. Thermocouples were laid on leaf surfaces and held in place by tape. Water collection cans were placed along a radius to measure the depth of water applied. Thermocouples, thermometers, and plants were placed outside the wetted area for checks. The first test was made on the early morning of May 9, 1950. Irrigation started at 2:40 a.m. when the air temperature at plant level had reached 33F. A thermocouple in the base of the sprinkler measured the water temperature which throughout the test ranged between 69 and 72F. Most of the heat in the water was apparently lost to the air before the water reached the plants. Temperatures recorded in the water-collection cans ranged between 33 and 36F. The lowest temperature recorded at plant level outside the wetted area was 28F. A thermocouple placed on a leaf 25 ft from the sprinkler recorded a minimum temperature of 28F. The water application at this point averaged 0.001 in per hr; both the blossoms and leaves were damaged. Another plant placed 20 ft from the sprinkler received 0.06 in per hr; the plant was damaged by frost. A third plant located at 15 ft from the sprinkler received 0.147 in per hr. The plant and blossoms were not injured. The time of rotation of the sprinkler was 2 min, 44 sec.

A second test was made on October 25 and 26, 1950. Tender green beans in pots from a greenhouse were used in this test. The water application was started at 8:40 p.m. and continued until 10:38 a.m. Light breezes at times approaching calm were prevalent. This resulted in considerable fluctuation in the plant level temperature. The lowest temperature recorded during this test was 24F. The bean plants that received a water-application rate in excess of 0.19 in per hr were protected while those plants that received 0.07 in per hr were frozen (Fig. 4).

A third test was made in a field area of lima beans on September 29, 1951. Sprinklers using a 7-deg $\frac{7}{32}$-in nozzle rated at 9.4 gpm were placed at 60x60 ft intervals on two laterals. Each sprinkler protected a circular area 54 ft in diameter against a minimum temperature of 28F.

The fourth test in this series was made in the fall of 1952. Standard two-nozzle sprinklers were placed on three lateral lines at a 100x100 ft spacing in a field of tomatoes. The sprinklers were equipped with $\frac{5}{32}$ x $\frac{13}{64}$-in nozzles. The $\frac{13}{64}$-in nozzle was replaced with a pipe plug. The gallonage of water delivered was 8.8 gpm per sprinkler.

A light frost of 30F minimum occurred on the night of October 2 and 3. The equipment operated satisfactorily and no damage was apparent on the protected area. A second frost occurred on the night of October 5 and 6. The equipment was started at 8:30 p.m. A minimum temperature of 24F was reached. Many of the plants in the irrigated area showed some damage. The time of rotation of the various sprinklers varied between 1½ to 4 min. It is possible that the speed of rotation may have been too slow. The heat of fusion given off by a new layer of water as it turned to ice was apparently dissipated and the temperature of the leaves fell to too low a temperature before a repeat application was made. Since freezing temperatures persisted for over 12 hr, there may have been factors of thickness of ice coat in relation to water application and also duration of freezing temperature entering into the results.

Further detailed tests are needed to determine the interaction between rate of application, duration of frost, minimum temperature, and rate of sprinkler rotation.

IRRIGATION OF FIELD CROPS

Potatoes. Because many of the soils in Michigan are of sandy loam texture, a large portion of the state is adaptable

to potato production. In 1952, 56,000 acres were devoted to the production of 10,360,000 bu of potatoes. Many of these growers have turned to irrigation as being essential to the production of high-quality potatoes. Deficient water supply in the growing season creates hollow hearts and knobs, to which the consumer objects. Wheeler (11), on the basis of field observations and exploratory tests, makes the recommendation that after good fertilizer and soil management practices have been established, yields can be increased by an increment of 100 to 300 bu per acre by the use of irrigation.

Pasture. Irrigation studies have been conducted for the past 4 years on Ladino clover and brome grass pasture plots by the farm crops department. These plots were grazed by sheep. Tesar (12) reports that the magnitude of animal gains, forage production and profit due to irrigation are encouraging.

In 1952, the study was expanded to include duplicate six-acre plots of Ladino clover, alfalfa and brome on a Fox sandy loam soil. Data collected included the production of the dairy cattle, their grain requirements, the forage produced and available moisture content of the soil profile at 6, 12, 24 and 36-in depths. One application of 1.5 in of water was made on July 2 and 3. The rainfall for the summer months was 0.13 in short of the May through September normal of 16.93 in. While a small gain for irrigation was recorded, it did not represent a financial gain over cost. Additional data are needed to complete the over-all picture. While we are not strongly recommending pasture irrigation, we believe that some profit can be made from the irrigation of desirable grass legume combinations on well-fertilized and well-managed light soil pastures.

EQUIPMENT

Portable irrigation systems composed of quick-coupling, light-weight pipe and rotary sprinklers are most popular with Michigan growers. Many of the earlier pumping units were made up of centrifugal pumps commonly powered with old automobile, truck or industrial engines. These units are being replaced with packaged pump and power units mounted on skids or trailers. Since three-phase electric power is not readily available, and since the hours of operation of the irrigation system are relatively short each season, gasoline engines have been the favored type of power.

The acreage irrigated by individual growers ranges widely from a fractional-acre strawberry patch to truck and potato areas of over 100 acres. While detailed survey information is not available, it is estimated that a majority of the pumping units operate in the 250 to 500 gpm range.

WATER SUPPLY SITUATION

Closely associated with the economics of supplemental irrigation is the question of water supply and water rights. About one-half of the irrigation water used in Michigan comes from surface sources; many lakes and streams are found throughout the state which provide an excellent source of water. Generally, farm ponds are not feasible for irrigation because of their limited capacity and difficulty in sealing.

The over-all water supply for irrigation in Michigan is good. At the present time, however, the situation regarding the water rights of irrigators is clouded and confused. With respect to ground waters, the courts generally hold to the rule of reasonable use. No legislation has as yet been developed to cover the anticipated increase in ground water use.

The farmer's legal right to use surface waters for irrigation in Michigan is governed by the riparian doctrine. Up to the present time, the courts have not as yet recognized irrigation as a legal riparian use of surface water. Until the courts act on this point, an irrigator cannot be certain as to what his rights are.

FUTURE OF IRRIGATION IN MICHIGAN

The increasing national concern about the source of additional food and fiber to meet the needs of our rapidly expanding population is a challenge to the agricultural research worker to find ways of increasing the production of the land now in cultivation. Both drainage and irrigation have a contribution to make in this increased production program. In Michigan, it is reasonable to assume that with a growing industry, the demand will increase for truck and small fruit crops. This will probably mean a shift in the land use of some of our sandy and sandy loam soils from field to truck crops. The expanded use of irrigation will parallel this expansion of the truck and small fruit crop production. It is also reasonable to expect that additional areas of muck soils will be added to the truck crop acreage; again, irrigation will be needed on many of these fields. With the shift of some field crop land to truck production it can be expected that many acres presently classified as marginal sands will be brought into production for livestock pasture through the use of fertilizer and irrigation.

Preliminary work is being started to determine the feasibility of field crop irrigation . While the need for irrigation of some of our deep-rooted crops on finely textured soils is somewhat in doubt, except in extreme drought years, the need for irrigation of field crops on sandy soils should be investigated. Studies of this type should include fertilizer rate, plant population, variety, and good soil management aspects to determine the maximum sustained production that can be attained when the lack of water is eliminated as a limiting factor.

It can therefore be anticipated that Michigan farmers will continue to expand their use of irrigation equipment. Many long-time truck crop irrigators no longer consider an investment in irrigation equipment as just "drought insurance."

With the aid of a stepped-up education program and with more field experience, more irrigators are realizing that their equipment can be used to greater advantage for emergence, transplanting, wind erosion control on sand and muck, applying soluble fertilizers, frost protection, and soil moistening for easier plowing.

Thus irrigation equipment is gradually becoming a part of the truck grower's standard farm equipment.

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Runoff from Conservation and Non-Conservation Watersheds

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CHANGES in both the peak rates and total runoff that may be brought about by changes in land use and the application of soil and water conservation practices are of importance to both agriculturists and engineers. In order to provide information of this kind for small agricultural watersheds, hydrological studies were initiated by the Soil Conservation Service during 1937 and 1939 near Coshocton, Ohio; Waco, Tex. and Hastings, Neb.

Near Hastings, Neb., a 481-acre watershed (W-3) and a 411-acre watershed (W-5) were selected in 1939 for detailed study. Both areas were farmed in straight rows until the spring of 1947 and records kept of runoff from each. Since that time some conservation practices have been applied on Watershed W-5. By the fall of 1950, 65 percent of all the planned terraces were completed, grassed waterways were established, legumes were increased from about 1 percent to about 12 percent of the area, and the grassland increased from about 17 percent to about 32 percent of the area. These conservation measures were applied with the cooperation of all but one of the landowners. This owner has about 43 acres of cultivated land at the head of the watershed which have not been protected by conservation measures.

The rainfall period of record on these two watersheds was compared with the long-time record at Hastings, Nebr. The accumulated rainfall at Hastings for the period 1895 to 1952 was plotted (Fig. 1). Using 1939 on this line as a new starting point, the accumulated annual rainfall on the two watersheds was plotted for the 1940-1952 period. Since wet and dry periods are indicated on Fig. 1 by differences in slope, it is apparent that from 1947 to 1952 the rainfall at Hastings was more than normal. The graph shows that rainfall received on the two small watersheds is comparable to the Hastings long-time record, although it is somewhat higher than the preceeding 20-year period which includes the drought of the 1930's.

The wide variation of yearly rainfall in the Central Great Plains region is another factor which was considered in evaluating the rainfall normality. The yearly rainfall at Hastings, for example, has varied from 11.90 in in 1936 to 40.60 in in 1915. Since the discussion to follow is divided into two periods, 1940 to 1946 and 1947 to 1952, a comparison is made of these periods in relation to each other and to the long-time period of record at Hastings. During the 7-year period, 1940-1946, the yearly rainfall was less than 20 in in 2 years, between 20 and 30 in in 4 years and above 30 in in one year. In the 6-year period, 1947 to 1952, the yearly rainfall was less than 20 in in 2 years, between 20 and 30 in in 3 years, and above 30 in in one year. The 1895-1952 record at Hastings shows that less than 20 in of yearly rainfall was received in 12 years, between 20 and 30 in in 37 years, and above 30 in in 9 years. This comparison shows the rainfall on the two watersheds is not only comparable in regard to yearly variation for the two periods, but is comparable to the variation in the long period of record.

During the period of record, 1940 to 1952, watershed W-5 consistently received about 3 percent more rainfall than watershed W-3, as indicated by the accumulated rainfall curves on the two watersheds (Fig. 2). The consistency of these differences in rainfall is further illustrated by plotting the accumulated rainfall on W-5 against that on W-3 (Fig. 3). These points plot in practically a straight line.

This paper was presented at the 46th annual meeting of the American Society of Agricultural Engineers at Pittsburgh, Pa., June, 1953, as a contribution of the Soil and Water Division. It reports the results of studies on a project of the SCS Central Great Plains Experimental Watershed, Hastings, Neb., in cooperation with the Nebraska Agricultural Experiment Station.

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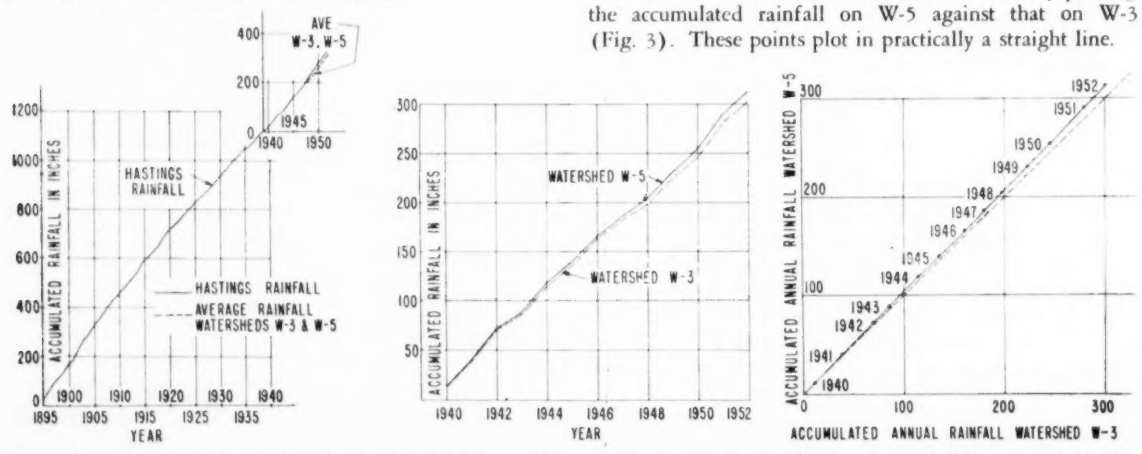
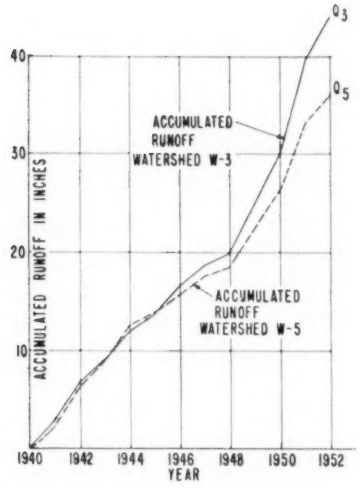
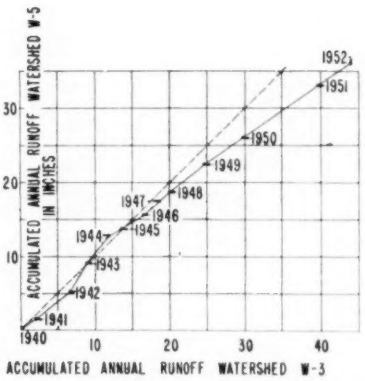


Fig. 1 *(Left)* Accumulated annual rainfall at Hastings, Nebr., 1895 to 1952, an average annual accumulated rainfall on watersheds W-3 and W-5, 1940 to 1952 • Fig. 2 *(Center)* Accumulated annual rainfall, watersheds W-3 and W-5, 1940 to 1952 • Fig. 3 *(Right)* Double mass annual rainfall on watershed W-3 plotted against accumulated annual rainfall on watershed W-5, 1940 to 1952





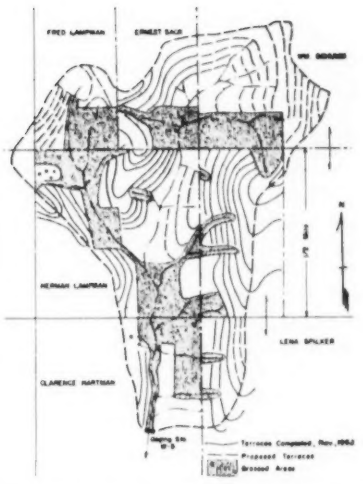


Fig. 4 *(Left)* Accumulated runoff, watersheds W-3 and W-5, plotted by years 1940 to 1952 • Fig. 5 *(Center)* Double mass curve of annual runoff, watershed W-3, plotted against accumulated annual runoff, watershed W-5, 1940 to 1952 • Fig. 6 *(Right)* This map shows terraces completed, proposed terraces, and grassed areas of watershed W-5

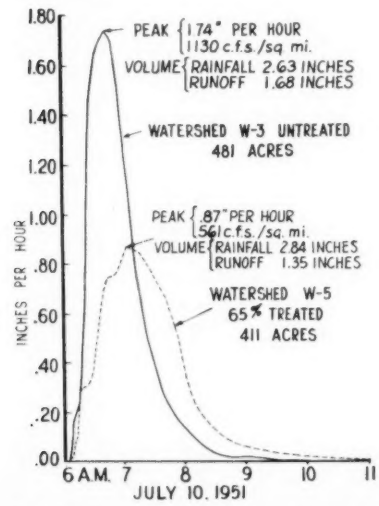
It is apparent that the differences in total rainfall on the two watersheds, although consistent, are relatively minor. Since rainfall is the primary source of runoff in this area, it should be expected that the peak rates of runoff, as well as the total runoff, from the two watersheds would be about the same where other factors are equal. A close similarity in runoff was observed during the calibration period 1940 through 1946, during which time the two watersheds were farmed in a similar manner. The records, however, indicate a definite trend toward lower peak rates and less runoff on watershed W-5 beginning in 1947, when the application of conservation measures was started.

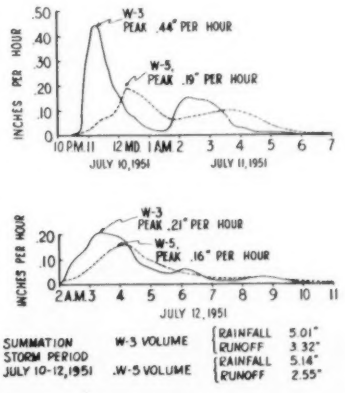
The accumulation of runoff plotted by years for each watershed shows that the runoff from the two areas was similar for the period 1940 to 1946 (Fig. 4). During the period 1947 to 1952, however, these curves tend to diverge from each other, indicating considerably less runoff from watershed W-5.

The effect of conservation measures on runoff is also indicated by plotting the double mass runoff curve (2)* for the two watersheds (Fig. 5). From 1940 through 1946, with possible normal deviations in data, the runoff from watershed W-3 is practically equal to the runoff from watershed W-5. This is indicated by a 45-deg line where $Q_5 = Q_3$. It had been previously shown by Potter (3), using the Gumbel probability method, that the runoff from the two areas is similar with respect to peak rates and total amounts for this period. Beginning in 1947 and at the time the application of conservation measures was started on watershed W-5, there is a decided breakaway from the 45-deg line, and the slope of the new line 1947 to 1952 is $Q_5 = 0.74Q_3$.

During the long-time period of rainfall record at Hastings, an average of 78 percent of the annual precipitation is received during the 6-month growing season, April through September. From 1940 to 1952 about 90 percent of all runoff from the two watersheds occurred during these 6-month periods. A double mass curve similar to Fig. 5

*Numbers in parentheses refer to the appended references.





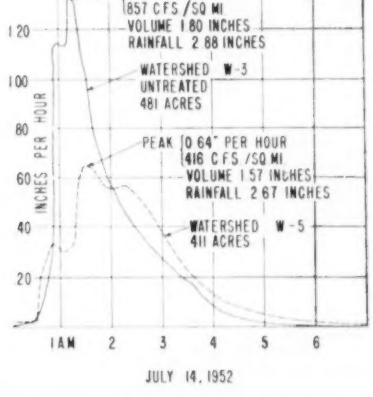


Fig. 7 *(Left)* and Fig. 8 *(Center)* Hydrographs for the storm period, July 10-12, 1951 • Fig. 9 *(Right)* Hydrograph of the storm of July 14, 1952

was plotted using the growing season runoff in place of the yearly amounts. These curves, which are not presented in this paper, show the same relationship and trends as Fig. 5.

By the fall of 1952, 68 percent of all the planned terraces had been built in watershed W-5 (Fig. 6), which is an increase of 3 percent over those built prior to the fall of 1950. Other practices were also increased slightly, but the watershed was in a relatively stable condition during the period 1950 to 1952. Farming practices on watershed W-3 remained the same. The accumulated mass runoff comparison for the 3-year period 1950 to 1952 showed the relation between the two watersheds to be $Q_5 = 0.71Q_3$, using yearly records, and $Q_5 = 0.73Q_3$, using the 6-month growing season records. These results indicate that even the incomplete application of soil conservation practices on a 411-acre watershed in south central Nebraska reduced the total runoff nearly 30 percent.

Peak rates of runoff also were much less from the partly treated watershed than from the watershed farmed in straight rows (1). Hydrographs were plotted for the highest individual storm periods in 1951 and 1952. The hydrographs for the storm period July 10 to 12, 1951, (Figs. 7 and 8) indicate that, even though the ground was well supplied with moisture from previous storms, the peak rates of runoff from the early morning storm of July 10 and from the storm of the night of July 10-11 were only half as high on W-5 as on W-3. The hydrograph of the storm of July 14, 1952, (Fig. 9) shows the peak rates of runoff were also only half as high on W-5 as on W-3. Table 1 shows the maximum yearly peak rates of runoff on both watersheds during the entire period of record.

TABLE 1. MAXIMUM YEARLY PEAK RATES OF RUNOFF IN INCHES PER HOUR AND CUBIC FEET PER SECOND PER SQUARE MILE

Year	Watershed W-3		Watershed W-5	
	iph	cfs per sq mi	iph	cfs per sq mi
1940	0.05	31	0.01	6
1941	0.53	341	0.25	160
1942	0.20	126	0.66	428
1943	0.35	225	0.84	545
1944	0.42	303	0.80	517
1945	0.17	110	0.18	116
1946	0.51	330	0.23	148
1947	0.30	190	0.16	102
1948	0.43	277	0.26	171
1949	0.59	383	0.67	434
1950	0.57	370	0.56	363
1951	1.74	1130	0.87	561
1952	1.33	857	0.64	416

In conclusion, it may be stated that the data collected on this project have shown a definite trend toward lesser peak rates and total runoff on a small conservation-treated agricultural watershed than an untreated one in the Central Great Plains Region.

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Supplemental Irrigation on Sandy Soils

(Continued from page 765)

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Flow Patterns of Air

(Continued from page 758)

An independent check on this calibration of the flow net is possible based on the total delivery of the fan. The volume of air moving through a slice one foot thick can be closely estimated. This volume divided by the number of flow channels shown in the flow net provides the desired second evaluation of cubic feet per minute per flow channel. These two evaluations were in good agreement for these tests.

The calibrated flow net thus developed now permits problems in the distribution of ventilation to be dealt with quantitatively. For example, one measure of efficiency is the ratio of the ventilation provided the least ventilated portion of the grain to the average ventilation provided.

Each flow channel of the calibrated flow net represents some known air movement expressed in cubic feet per minute per foot length of building, and also represents some number of bushels of grain per foot length of building. The area of each flow channel may be measured, for example, by planimeter (Fig. 11). This permits a separate value of cubic feet per minute per bushel to be established for each flow channel (Fig. 12). These separate values may then be rendered as a bar chart, from which a smoothly curvilinear diagram of the distribution can be drawn (Fig. 13). The minimum ordinate divided by the average ordinate is the efficiency ratio sought.

The test information secured during 1952, including the analysis of air distribution as expressed by flow net, provided the basis for design revisions which have now been incorporated in the Quonset 16 grain dryer (Fig. 14). In the 1953 Quonset dryer the plenum duct extends the full length of the building; the endwall linings are extended upward to permit grain to be piled to the same height from end to end of the building; these endwall linings are sealed against movement of air through the joints in their sheeting, and there are eight longitudinal vents in the sidewall lining sheets as compared with two such vents in the 1952 design.

Additional tests are planned for 1953. These new tests should add substantially to our 1952 data, and will also be aimed at questions of farm-operating techniques for the Quonset 16 grain dryer.

Water Rights and Administration with Respect to Soil and Water Conservation

C. E. Busby

MODERN society in America, with its growing emphasis upon intensive use of land and water resources, needs improvements in or additions to our systems of water rights and administration. By such means conflicts of interest over water can be minimized and the growth of important areas of the nation maintained in accordance with their capabilities. Strengthening of the systems governing relations between and among people and their institutions in the field of water and related land use might begin with more enlightened attitudes of mind. These would be attitudes which give greater recognition to the rights and responsibilities of others, which recognize the vast experience of the western states, and which help to lead others to assume their proper responsibilities and to utilize this experience through orderly democratic procedures[1].

This process has been going on at a rather rapid pace in the West ever since the early American occupation. But in the East the process has been lagging far behind. In fact, parts of the eastern system are just about where they were during the first half of the 19th century[2].

It should not be assumed, however, that the western system is perfect or complete by any means. In fact, certain phases of the water rights and administrative systems of some states in the West are inadequate to meet present as well as future needs[3].

The purpose of this paper is to set forth briefly some of the factors which give rise to water problems having legal and administrative implications, together with certain trends in those factors; to analyze briefly the soil conservation movement with special reference to broad responsibilities for soil and water which have been, or should be, assumed by soil conservation districts and farmers; and finally to outline some of the rights and responsibilities of land and water users, local agencies, and the several states wherein water laws and administrative systems need to be improved. This will serve to point up and emphasize only the main points which might be recognized and considered.

Factors Giving Rise to Water Problems Having Legal Implications. It has been said that water problems arise out of too little or too much water, and that this simple substance has seldom been available in exactly the right amount, at the right time, and in the right place. Too little water results from drought, rapid development or over-development and use, lack of storage or replenishment, and reduction in the usable supply through impairment in the quality of water by sediment, industrial and human wastes, and salt encroachment. Too much water results from excessive precipitation and runoff, poor land use practices, and barriers to water movements over and through the land[4].

Thus it appears that the three main limiting aspects of water -- amount, time and place —may be keys to our future economic development and progress in many fields. Ask anyone who tries to irrigate from a stream which goes dry just at the place and time when the water is needed most. Ask anyone who plans to establish a modern factory calling for the expenditure of millions of dollars. Or ask the housewife who is responsible for the cleaning, washing, cooking and many other tasks calling for water now — not next week or next year.

All too often adequate supplies of good quality water and effective systems for water disposal are taken for granted. When the supply runs out at a critical time and place, users begin to blame someone else. Or when systems for the disposal of water are inadequate, people begin to blame their neighbors residing above or below them. If people are to avoid legal and administrative problems growing out of shortage and excess of water, they need to look ahead and anticipate changing needs—physical, economic, legal and administrative. But to cope with the changing needs in the physical and economic fields often requires consideration first of laws and administrative systems — because changes in water use and management may not be made haphazardly[5].

After all, water in its relation to the land is real property in which there is a very considerable community of interest arising out of its moving and essential character. And since real property is the primary responsibility of the several states, the states are vitally concerned with water use and management.

Water use and management problems having legal implications seem to vary according to the occurrence of the three main limitations of water indicated above and also with many other influences too numerous to mention. This is not new by any means, for these problems have been occurring since long before the birth of Christ — if laws established then may be taken as any criterion[6].

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Pittsburgh, Pa., June, 1953, as a contribution of the Soil and Water Division.

The author — C. E. BUSBY — is soil conservationist, Soil Conservation Service, U. S. Department of Agriculture (Berkeley, Calif.), and member of the District of Columbia Bar.

[1]This paper is directed mainly to the 31 eastern states, and particularly the seaboard states of that area. See also Hutchins, Wells A., Water rights for irrigation in humid areas, AGRICULTURAL ENGINEERING, vol. 20, November, 1939.

[2]Busby, C. E., American water-rights Law, South Carolina Law Quarterly, December, 1952; the beneficial use of water in South Carolina, preliminary report, U. S. Soil Conservation Service, February, 1953.

[3]For example, California does not have a comprehensive ground water statute, yet it has some of the most complex ground-water and related land-use problems. Also, the standards of beneficial use of water adopted by the courts in most western states are not up to the better standards of such beneficial use.

[4]Bennett, H. H., Water in the ground: too much or too little water, Soil Conservation, Vol. XVI, February, 1951.

[5]See, for example, Adams, Frank, Irrigation in California as viewed from the side lines, California Farm Bureau Monthly, March 1953. (Of nine points listed as largely responsible for irrigation progress in California over the last fifty years, the first four were legal.)

[6]Report, Preservation of integrity of state water laws, Appendix G, October, 1942.

Trends in Factors Giving Rise to Water Problems Having Legal Implications A very large part of all our water development and conservation work took place between the first and second World Wars. Along with this came pronounced changes in concepts of water rights, especially in regard to such matters as: What constitutes a navigable stream? Who has the rights to energy produced by falling water and under what circumstances? And what types of organizations should develop systems of control for streams?[7]

An even more rapid rate of expansion in the use of water, at least for certain types of uses and certain localities, seems to have taken place during and since World War II[8]. Along with this expansion have been serious droughts (which have reached into the New England states), the continuing pollution of streams, lack of sufficient storage capacity, and changes in agriculture, industry, towns and cities. Combinations of these influences seem to be causing water-shortage problems in areas where problems of excess water have been prevalent for many years.

This situation seems to have been more acute in the seaboard states of the nation, but it has also appeared at inland points as well. The South and Southeast seem to have come in for a variety of these changes. It remains to be seen whether or not this trend will continue into the future. Certainly some of the factors contributing to intensive use of land through irrigation and drainage, to the migration of industry, and to the growth of towns and cities would seem to be of the type which may continue in the South and Southeast for some time to come.

TRENDS NOT INDEPENDENT OF SOIL CONSERVATION

These trends have not been independent of another great movement — that of soil conservation which has reached into every one of the 48 states and into the territories[9]. In fact, it appears that the broad social and economic trends just outlined and the soil conservation movement are rather closely related locally. The main economic interests in both movements seem to be dependent upon the same sources of water supply. They are affected by the same types of water damage.

One aspect of this relationship is not generally recognized, however. That is the fact that the vast majority of the water supply of most of our states, except for water imports from other states, and also the source of much of the water damage originate upon non-urban watershed lands which are used and managed largely by farmers and ranchers. Thus farmers and ranchers occupy a very special position in this field of water rights and responsibilities. For this reason, it may be well to analyze and consider some of the broad trends in the soil conservation movement itself which is under the direction of landowners and operators in over 2500 organized soil conservation districts.

[7]Report, President's Water Policy Commission, Water Resources Law.

[8]Inventory of water and sewage facilities in the United States, U. S. Public Health Service, Federal Security Agency, Cincinnati, Ohio, 1945; MacKichan, K. A., Estimated use of water in the United States — 1950 U. S. Geological Survey Circular 115, May, 1951; McGuiness, C. L., Water situation in the United States with special reference to ground water, USGS Cir. 114, p. 87, June, 1951; Paulsen, C. G., Our water supply, USGS, March, 1953. Personal discussion with members of the staff of the state engineer, Sacramento, Calif., 1953.

[9]Soil Conservation Districts (Mimeographed report of the U. S. Soil Conservation Service, released July 1, 1952.)

The Soil Conservation Movement in Its Inception — The Soil Phase. In its inception in the depression years, the soil conservation movement developed mainly around the *soil phases* of a well-rounded soil and water conservation program. Experiment stations and demonstration projects were in operation in many states. These helped materially in developing and demonstrating improved ways to control soil erosion and prevent soil losses.

Through this experience, it became evident that the people living on the land exercise tremendous influence upon the soil and its productive capacity. They determine the land ownership and land-use patterns.

With the natural landscape cut up into farms and fields, and with uses established often without regard to land and water capabilities, the forces of wind and water can begin their destruction. Since these forces follow only physical features of the landscape, it became evident that some type of organized group action would be absolutely necessary if soil erosion were to be checked and soil resources protected.

This was given tangible meaning in terms of the concept of soil conservation districts, which could cover many farms and often more than one county. Here is where the soil conservation movement changed from an approach largely physical in nature to one in which man and his neighbors play the dominant role; where our people and their state governments began to assume greater responsibilities for the use and management of their soil and some phases of their water resources.

There was considerable discussion then as to whether enabling legislation for these group organizations should be federal or state. The state basis was suggested because land is real property and real property is the primary responsibility of the several states[10].

The authority of each state legislature was essential in order to carry out programs affecting real property. Here is where the state legislature developed statewide enabling legislation for soil conservation districts. Here is where land users were able to organize into effective local agencies, so that they could assume greater local responsibility for conserving their soil through cooperative activities.

POWERS GRANTED TO CONSERVATION DISTRICTS

Powers granted to soil conservation districts did not extend to the planning, execution and financing required for construction, operation, and maintenance of group water projects. However, the districts did obtain broad powers to deal on a cooperative basis with some of the more important phases of water management on the farm or small group of farms, especially that phase which will later be referred to as diffused surface waters[11].

The Soil Conservation Movement Today — The Water as Well as the Soil Phase. Soil conservation districts have carried on good land-use and soil conservation programs for upwards of 15 years, and new districts are being formed every year. In this work, district supervisors, directors or commissioners have acquired considerable administrative and leadership experience which has put them in a good position for assuming larger *(Continued on page 772)*

[10]Glick, Philip M., The soil and the law, Yearbook of Agriculture, 1938, pp. 296-318, 299, 300.

[11]It should be noted, however, that the soil conservation districts' law of California was amended in 1951 to provide certain additional powers for soil conservation districts in the field of water.

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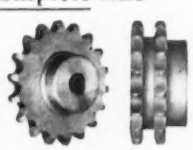

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Water Rights and Administration

(Continued from page 770)

responsibilities as they arise. They have acquired broad points of view and attitudes of mind.

As their work has progressed, district leaders and their assisting technicians have been confronted continuously with water problems of all sorts which affect land use and farm enterprises. Some of these involve the *use* of water, such as is encountered in shifting from row crops to grass and trees, or vice versa; in providing adequate supplies of good quality water for livestock, wildlife and recreation on the farm, and in developing irrigation systems and applying sound irrigation practices.

The *damage* aspects of water have also come in for consideration, such as those involved in establishing water-disposal systems to improve wet lands, in controlling major gully erosion problems, and, in more recent years, in preventing and reducing floodwater and sediment damages.

Some farmers have also lost their good-quality water supplies, for temporary or longer periods, through competition arising out of the rapid expansion in the development and use of surface and ground waters and through other causes.

As these more exacting and technical conservation problems were encountered, it became evident that the *water phases* of this total conservation job are more complex than had been thought in the beginning. Water, though a simple substance, follows certain physical laws concerning which most farmers have not had extensive training and experience.

ALTERING THE PATTERN OF WATER MOVEMENT

In attempting to alter the movements of water over and through their lands, farmers have in some instances, and possibly at times without realizing it, modified the extent to which they and others could *utilize* these water supplies or be *damaged* by them. As people alter the pattern of water movements in an area, they may thereby affect not only their own but also other people's water rights and investments. Here is where new problems and responsibilities arise in soil conservation districts.

Furthermore, land users are coming to realize more and more that water, as well as land, has certain capabilities. This is especially evident when a soil conservation district or an entire state is the subject of consideration. As the programs of soil conservation districts move more and more into the *water phases*, district leaders may need to consider these broad water capabilities. Here is where their points of view can and will broaden still more. They may also need to recognize, in dealing with water problems, that other groups such as the industries, municipalities, and recreation groups are also concerned.

If there is any resource which calls for cooperation in its use and management, it is water. One place to establish cooperation is in laws and administrative systems.

The Water Phases of Soil Conservation Involve Law as Well as Engineering. Land users and district leaders need to concern themselves not only with engineering and other physical sciences, but also with the law and its administration. Both are highly technical fields. It is important that they be understood and utilized as much as possible. Any time that land and water users get very far away from sound principles of engineering and law, they encounter difficulties. Any time that one water-using group does not work closely with the other water-using groups on problems of mutual concern, difficulties are bound to arise.

Much of our system of water rights was developed when little was known about the behavior of water, particularly that of ground water. As a result some of our water-rights principles and administrative systems are not adapted to conditions as they exist today. Today, many of our water uses are artificial ones while those of the early settlement of the eastern states were natural uses.

The main water problem for the states, concerned local agencies, and land and water users seems to be how best to balance supply and demand for water within and between water-problem areas and how best to minimize within practical limits the damage caused by and to water resources. The right combination of vegetative and structural measures on the one hand, and of legal and administrative measures on the other hand, seem to offer the best chance for permanent solution.

Soil conservation district leaders and their assisting technicians have not always known how best to deal with these more complex water-use and management problems. Yet they are faced with leadership responsibilities for the administration of their district programs and also, as a matter of greater service, to other groups concerned with natural resouces and to their fellowmen.

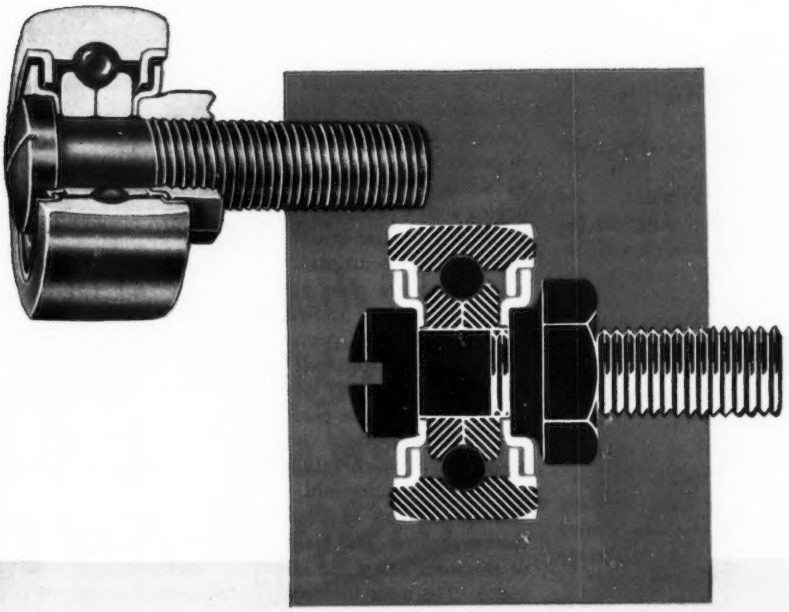
With the thought in mind that understanding of some of the basic principles of American water rights and responsibilities are essential to the solution of these problems, the remainder of this paper is devoted to these matters. An effort will be made to emphasize phases of water rights and administrative systems needing strengthening. This strengthening might take the course of development of comprehensive water codes under the leadership of water users and their advisers, members of the legislatures, and the governors of each state. Each state needs to be treated as a separate problem.

Water Rights and Responsibilities in General. The general system of our American water law is made up of basic property rights and water organizations. Each of these major categories involves the *damage* and the *use* aspects of water as they relate to the land. But the *use* and *damage* aspects are not always clearly distinguished by the courts and administrative agencies.

GROUP ORGANIZATIONS AT THE STATE LEVEL

Group organizations consist of public agencies at the state level, or irrigation, drainage, flood control, soil conservation and other districts at the local level. There are also private partnerships and corporations which have limited responsibilities. These legal means of approach to provide water for *use* and to reduce *damage* recognize that some water activities need to be carried out cooperatively as group undertakings.

Local agencies and organizations should consider these aspects of their larger water problems in due course, if they are to meet their needs for irrigation, drainage, flood damage prevention, and watershed protection, and to attain some reasonable means of control of groundwater use and artesian pressures. Such consideration should involve research into existing administrative experience, as well as the law, and should not be acted (Continued on page 774)



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Water Rights and Administration

(Continued from page 772)

upon without due consideration of water and other basic property rights.

Water rights are divided with respect to water in the air, water on the surface of the land, and water in the ground. Surface water rights are further divided with respect to watercourses, having well-defined channels, and diffused surface waters, which have not found their way into well-defined channels but which may follow minor depressions or drainageways.

Groundwater rights are divided much the same as surface water rights. First, there are rights in subterranean streams, having well-defined channels, and, second, rights in percolating ground waters, without well-defined channels but which follow minor cracks or porous zones.

To each of the subdivisions of surface and ground-water rights, somewhat different rules of law and administrative principles apply with respect to permissible *use* and *damage* resulting from artificial alteration in water movements[12].

Rights to Water in the Air — Responsibilities of the States and Congress. Each state has certain rainfall characteristics. Moisture in the air is a valuable resource, including its absorbed nitrogen and other elements, just as water on the land or in streams is valuable[13].

The courts and legislatures have not spelled out the character and extent of private and public rights to water in the air. This is no reason for saying, however, that none exist. Artificial rainmaking, such as is taking place in some states, even in the East, may speed up the processes of the courts and legislatures[14].

PROTECTION OF WATER SUPPLY FROM THE AIR

It would seem that people who acquire lands, and water rights in streams and lakes, should be protected in their natural source of water supply in the air. They should not be unduly deprived of their precipitation by others who, by artificial means now available, might find it possible to divert large quantities of moisture-laden air for use in other localities or states.

Of course, moisture-laden air in excess of the reasonable needs of land and water users in one locality might be considered to be available for use in other localities at certain times of the year. These aspects of the law of water rights are so nebulous at present that one can only hazard a guess as to what the law might be determined to be eventually. It would seem to be the responsibility of the state legislatures and the Congress to begin to formulate policies in this field before artificial rainmaking gets out of hand[15].

Rights to Diffused Surface Waters on the Land — Responsibilities of Land Users and Local Agencies. A very sizeable percentage of the water that falls on the land as rain or snow is consumed in evaporation and transpiration. If the land user is able to convert more of this into productive transpiration through useful plants, he usually gains both in terms of production and of reduction in *damage* caused by water. Thus the initial phase of water conservation begins with wise land and water use.

Another phase involves the application of conservation practices to help maintain productive capacity, and not only hold the soil in place but also increase the infiltration of water into the soil and reduce the surface runoff.

A third phase concerns structural measures such as dikes, diversion ditches, ponds, and detention or storage reservoirs to slow up the movement of water. The right combination of these phases of water management can make possible the beneficial consumption of a large part of total precipitation which falls upon a farm or group of farms.

The upper portions of many watersheds are steeply sloping and may require more intensive use of certain of these measures. The lower portions may require other types of measures to get rid of excess water whenever it accumulates. The more intensive the treatment, the greater is the need for water rights and responsibilities to be considered.

Generally speaking, the land user is said to have a right to use and control his diffused surface waters by various management measures, just so long as his use is a reasonable one in respect of his neighbors, and just so long as he does not unduly or carelessly collect, concentrate, and discharge these waters upon his neighbors in such unnatural quantities and velocity as to cause substantial damage.

In some states, the upper landowner has the right to have these waters go down to and pass over the lands of his neighbors without undue interruption as they would naturally flow. But his neighbor also has an equal right to have these waters go down to and pass over the next succeeding tract of land in similar manner.

RIGHT TO USE AND CONTROL OF SURFACE WATERS

It would seem, as a matter of principle, that the landowner by reason of his ownership should have first claim upon the use of these waters for his reasonable needs. But such a first claim ought to carry with it a duty or responsibility to his neighbors and to others far downstream so to use and manage his diffused surface waters and land as will aid others in making use of, or in avoiding damage caused by, the residual runoff or stream flow. Such a first claim ought also to carry with it the duty so to use and manage diffused surface waters and land as will aid in developing and protecting their inherent capabilities for future generations and in minimizing damage within practicable limits. Some of these aspects of water use and management have not been spelled out in our customs and laws. It would seem wise that they be given consideration in due course as one basis for furthering soil and water conservation programs[16].

(Continued on page 776)

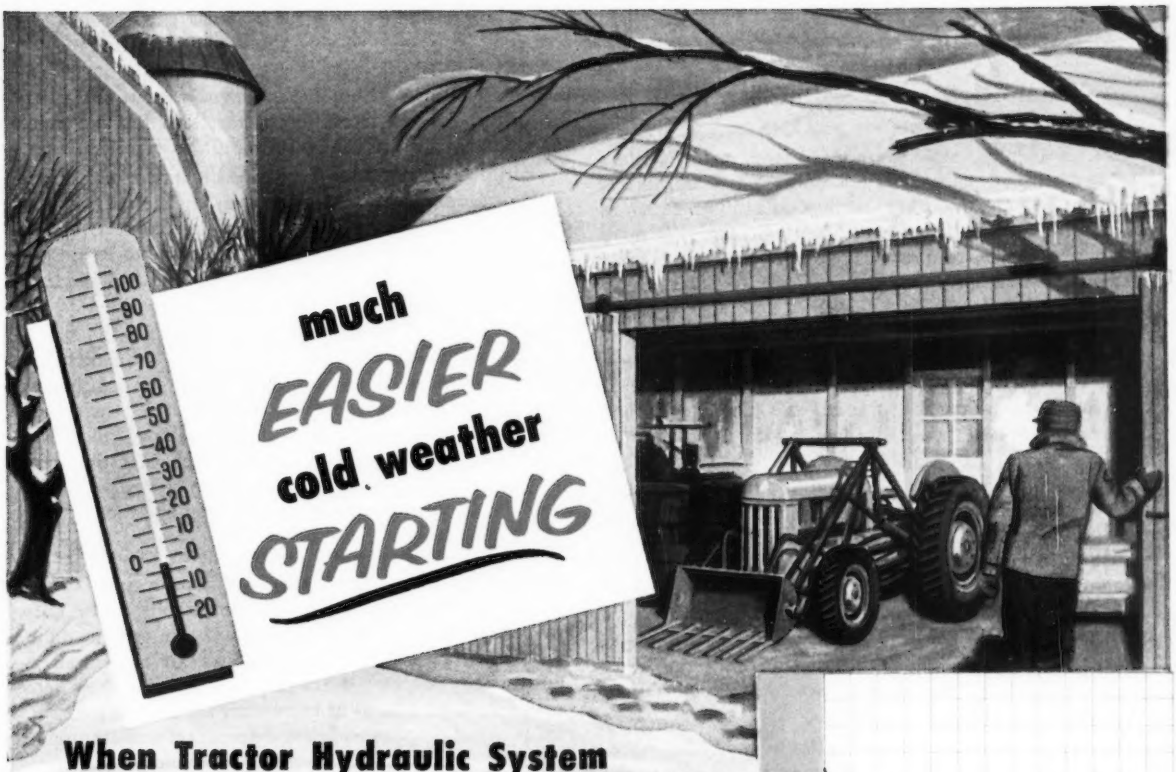
[12]Hutchins, Wells, A., Selected problems in the law of water rights in the west, pp. 1-24 (1942).

[13]Project cirrus, the story of cloud seeding, *General Electric Review*, November, 1952.

[14]4 Vanderbilt Law Rev., 332; 58 Yale Law Rev.; 1 Stanford Law Rev., 43; Craig, Gavin M., Legal aspects of rain making, and legal report on liabilities in creation of artificial rainfall and powers of the state to regulate the same, December, 1950.

[15]Bills have been introduced in Congress but none seems to have received acceptance as yet. The New York newspapers reported during April, 1953, that a bill passed by the New York legislature to license artificial rain making in that state had been vetoed by the governor for reasons specified.

[16]It should be noted here that greater care may be needed in using and modifying by artificial means the movement of diffused surface waters in the western states, for these waters are one source upon which downstream water uses are dependent. It may be that the landowner upon whose land the precipitation falls probably has only a qualified right to use diffused surface waters, with due regard to downstream rights. This question does not seem to have been squarely presented to the courts or legislatures (*a*) as between users of diffused surface waters and users of surface streams and (b) as between one user of diffused surface water and another user of diffused surface water. See Hutchins, op. cit., (footnote 12), pp. 110-121.



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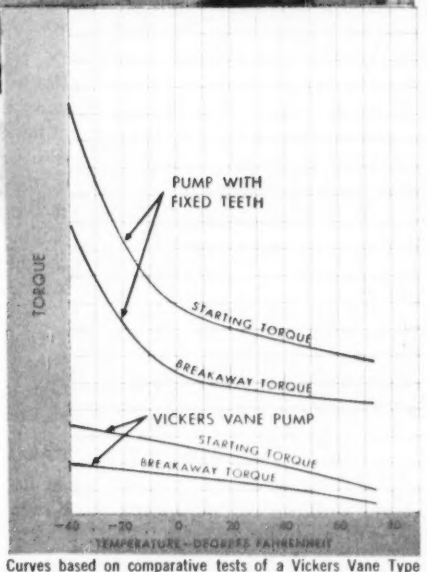

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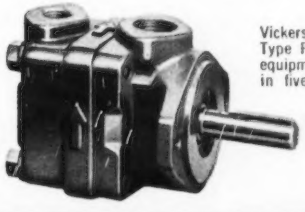

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Water Rights and Administration

(Continued from page 774)

In a sense, the people who use the land, mainly farmers and ranchers, are custodians not only of the agricultural lands but also of the diffused surface waters of a state. To some extent, they are also the custodians, together with other water-using groups, of most of the waters of a state because both stream flow and ground waters are supplied largely from diffused surface waters.

Here is where local agencies have a special responsibility in helping to set wise standards of use and management. These standards once wisely established on a sound local basis could become part of local custom. They might then be incorporated into the body of laws regarding water when widely accepted.

This whole field of water-land use and management may call for considerable study, (1) to determine what is the exact status of the law, and (2) to develop improved principles to guide land and water users for various types of topographic situation. Here is where the American Society of Agricultural Engineers can make a very real contribution. Its members could offer helpful ideas and suggestions on how best to employ sound engineering principles in developing improved systems of water law and administration.

Rights to Stream and Lake Waters — Responsibilities of Local Agencies and the States. Of that portion of the precipitation which runs off the land, some percolates into the ground and some continues as stream flow moving into the rivers and sea. That portion of the surface runoff which moves slowly combines with some of the ground water to make up our less fluctuating and more dependable stream flow.

The portion of the runoff which moves rapidly takes with it large quantities of eroded soil, and causes erosion and floodwater and sediment damage. Where surface runoff moves slowly in "flat" country, however, it tends to add to and build up the water table so high that "sobbing" of the soil takes place in some localities. Obstructions in streams may accentuate both of these problems of *damage*.

SURFACE WATERS IN DEFINED STREAM CHANNELS

When the diffused surface waters find their way into defined stream channels, they take on more of a public and less of a private character. There is a great community of interest in these waters, both from the standpoint of *use* and *damage*, which is properly of public concern. Part of this concern is local, part is statewide, and part is interstate.

Local agencies are vitally concerned with using stream flow locally for irrigation, livestock, municipalities and industries, as well as for recreation purposes, because it is a more dependable source of supply. In addition, they are concerned with the removal of excess waters from the land and their orderly disposal into natural stream channels. These channels need to be kept in suitable condition if they are to serve useful drainage purposes. Here is where the owners of adjacent lands as well as local agencies can assume a share of responsibility too.

Soil conservation districts lack sufficient powers to carry out the larger group jobs in these fields. In some states, however, counties, local courts, or drainage, flood control, conservancy or watershed districts may be authorized to do some of these things. Adequate powers should be provided these local agencies, either through improvements in existing law or through new legislation, so that local soil and water conservation programs can go forward in an orderly manner.

Once such powers were provided, farmers and others could organize more effectively to carry out the *water phases* of their conservation programs, just as they are carrying out the *soil phases*. This would make it possible to round out their programs of use and conservation — both on the farms and in the community watersheds.

The waters of streams and lakes, while flowing naturally, are considered to be the property of no one individual, except insofar as the constitutions, courts or legislatures have declared these waters to be the property of the people of the state. This concept of moving things, including water, wildlife and air, has been called the "negative community". It applies to our eastern system of riparian rights as well as our western system of prior appropriation.

WESTERN AND EASTERN RIGHTS SOMETIMES DIFFER

People or water organizations can acquire rights to use these waters under certain conditions established by state law. Here is where the western and eastern systems differ in certain respects. These rights of use are recognized as real property rights. But where waters are taken into possession, as in a canal or pond, they are generally considered personal property and then different rules of law apply. A notable exception in this regard is the rule now in effect in California.

The rights to stream and lake waters, however, are subject to the paramount power of the federal government to regulate navigable waters and protect their navigable capacities in the interest of interstate commerce. This is important in certain states, and has been since their early settlement.

Let it not be forgotten though that these waters are also subject to the inherent powers of the states to regulate water use and development in the interest of conservation and the health, safety, and general welfare of its citizens. Here is where the state legislature has the authority and the responsibility to adjust water laws and administrative systems to meet changing conditions. In some types of water problems the people of a given state may find it necessary to adopt constitutional amendments for certain of these purposes.

In the East and still to a limited extent in certain western states, rights to use stream flow and other major surface-water supplies are limited largely to those who own contiguous lands. These are called riparian rights. They must be exercised with a reasonable regard for the equal rights of all other riparian owners on the water body since the right of use of each owner in certain respects is limited by the rights of all other owners who may be affected.

One who uses these waters on riparian lands must return them to their natural channel before they leave his land. He may not divert the water from one watershed to another watershed so as to deprive succeeding riparian owners of their respective rights of use.

On the other hand, the western system of prior appropriation permits use of water both on lands contiguous to the stream and on lands which are not. To obtain its use, one must apply in most instances to the state agency administering water rights and development for a permit to divert and put a given amount of water to beneficial use and this within a reasonable time. *(Continued on page 778)*

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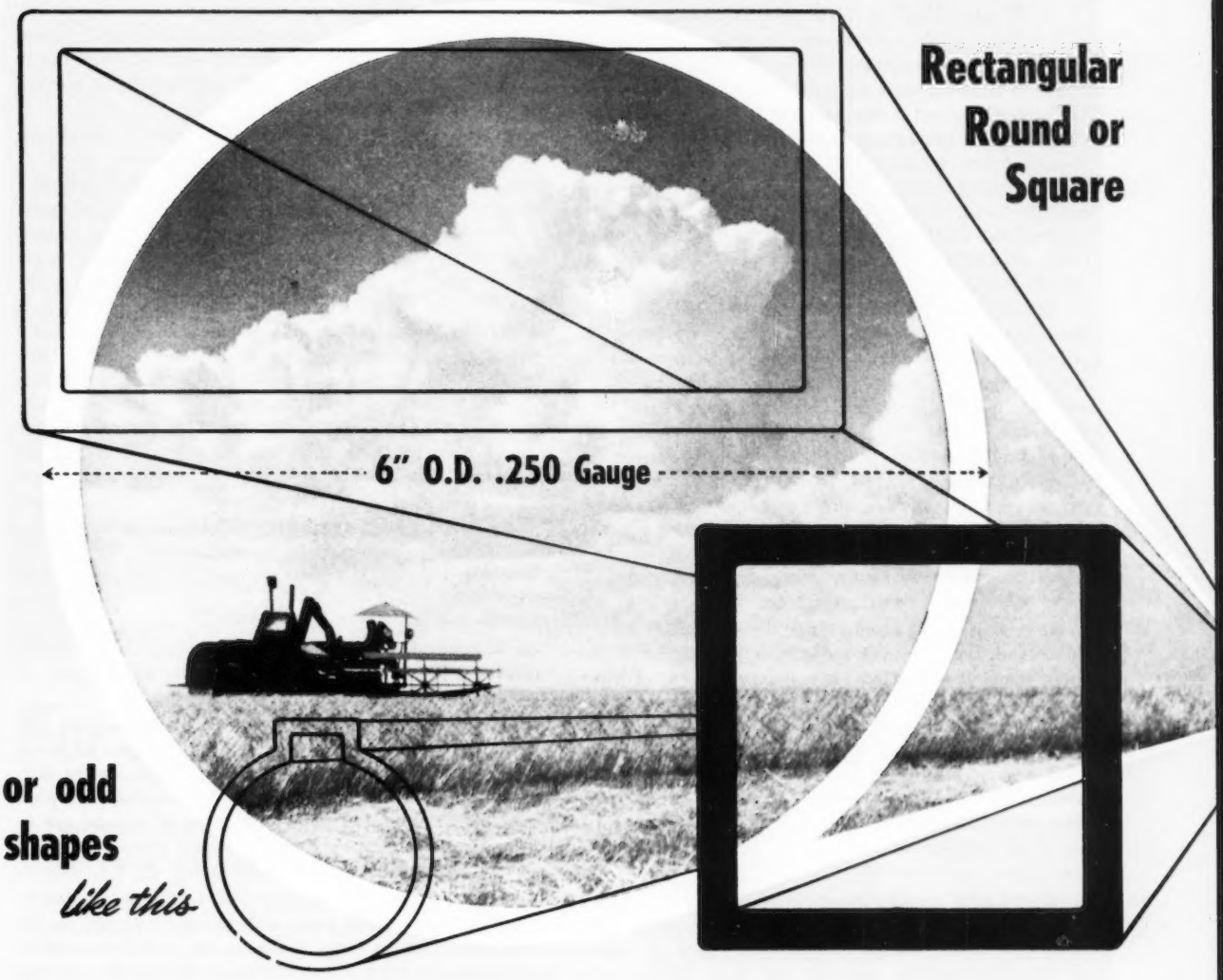

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Water Rights and Administration

(Continued from page 776)

When validly acquired, this is called an appropriative right. It is an exclusive right of use for those who comply with the statute and is recognized as real property. It is not limited by the corresponding rights of others, in the same manner as are riparian rights, but it is limited by the rights of other appropriators under the rule of beneficial use. However, the exclusive right of use of a given quantity of water at a given place and time tends to protect and encourage investments dependent upon water resources. It tends by reason of state policy, to emphasize beneficial use and conservation.

Naturally the western policy of prior appropriation has been gaining in favor in the West over the years. The policy of the riparian law has been losing favor there where water is so indispensable to economic development. It remains to be seen whether the eastern states will profit by this experience.

It would seem to be the responsibility of land and water users to use these stream and lake waters wisely, and of soil conservation and other local district leaders to help develop sound standards of beneficial use and management. It is the responsibility of state legislatures to provide effective legislation which will permit orderly development and wise use of these waters, as well as their conservation and protection.

In each of the 31 eastern states, the riparian law adopted in the early settlement of the state is the rule of decision for streams. It was adapted to a simple economy of natural water uses. It is not well adapted to an expanding and complex economy, to problems of shortage, and to orderly development and conservation. Here is a major area for needed strengthening in our system of water rights and administration. Here is where agricultural engineers can also make a real contribution toward the development of improved standards of use and management and improved principles of water law and administration.

Rights to Waters in the Ground — Responsibilities of Land Users, Local Agencies and the States. This brings us to the consideration of ground-water rights and responsibilities, which are considerably more of a problem.

SOME PRECIPITATION ABSORBED BY SOIL

As precipitation comes into contact with the soil, some of it is absorbed. Of that part which is absorbed, a portion goes to augment ground water, especially in the season of heavy precipitation and low consumptive demands of plants.

In some lower lying areas, the water table is sometimes so close to the surface of the land that irrigation, drainage, flood-damage prevention, and land-use adjustments are bound up with ground-water conditions. The shallow aquifers which hold this water are not always uniform in porosity, so that the occurrence of ground water may be spotty.

The more porous beds are often confined between impervious clay beds. As the ground water moves down slope within the porous beds from higher points of intake, it is subject to pressure from the long sloping column of water above. This creates artesian conditions.

As these beds are punctured by wells or shallow ponds, the water rises toward or flows at the surface. The more wells and ponds there are, the less pressure and in some cases, the less water is available for each user. The pressure may be reduced to the point where pumping is required. And where the rate of pumping exceeds the rate of replenishment, there may not be sufficient water to meet needs. Thus artesian pressure and water supply may be reduced beyond practical limits.

These losses may be very serious where livestock and irrigation are largely dependent upon ground water or where other uses are also competing with agricultural uses.

The careful spacing and use of wells, ponds, and drainage ditches is needed. Wells might be capped where they needlessly dissipate pressure and water supply. Some might be plugged, or certain horizons blocked off, if salt water from one bed is polluting fresh water from another bed. In special cases, artificial replenishment by wells or water spreading may be necessary to build up buffer zones to salt water encroachment or otherwise to conserve valuable ground water supplies. These measures may require regulation by law in one form or another. Obviously cooperative group action is essential if regulatory legislation is to be fully effective. This calls for considerable educational work.

In one of the states of the East, little or no ground water law has been spelled out at all. In most of them, little has been provided in the way of public policy to guide development along conservation lines. In some of these states, the landowner, by reason of his ownership, has been held to have a right to use this water as he pleases regardless of what effect it may have upon his neighbors. This is according to the legal concept that ground water is part of the land.

Ground water is not physically a part of the land, like stone, for it is continuously moving from higher to lower lying positions, albeit slowly. Thus this legal concept does not recognize sound engineering and geological principles. It would seem to contribute to conflicts of interest and to insecurity of investments dependent upon ground water [17].

In one or more of the other states, the landowner's rights of ground water use have been held to be limited by the rule that one may make such use as he pleases on his own land, just so long as this is not malicious, unduly careless, or the water is not exported to other lands—causing injury to the ground water supply of one's neighbors.

Land users and soil conservation district and other local leaders have responsibilities in this field of water management just as in the other fields. If this valuable resource is to be used and managed so that maximum beneficial use may be obtained of lands served by it, there needs to be some reasonable regulation of use to conserve the supply and pressure. In addition, effective disposal of surplus ground water ought to be made possible where "sobbing" occurs.

RIGHT OF USE OF GROUND-WATER SUPPLY

It would seem that the landowner, by reason of his ownership, should have first claim upon the use of these waters to meet his reasonable needs just *(Continued on page 780)*

[17] It should be noted that engineers and geologists have severely criticized some of these principles of ground-water law. See Thompson, D. G. and Fileder, A. G., Some problems relating to legal control of use of ground water, Jour. Am. Water Works Assoc., vol. 30, no. 7, July, 1938; Tolman, C. F. and Stipp, Amy C., Analysis of legal concepts of subflow and percolating waters, Trans. Am. Soc. Civil Eng., vol. 67, no. 8, part 2, October, 1941; Thomas, Harold E., The conservation of ground water, pp. 243-267, 1951, New York, Toronto and London.

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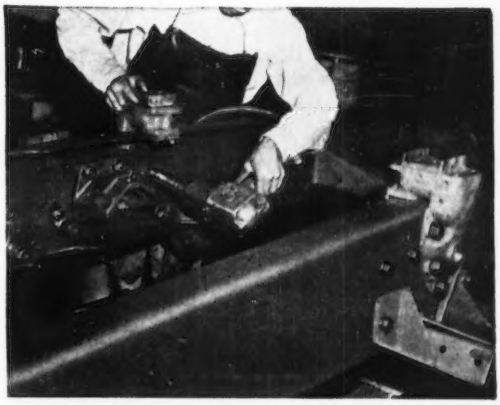

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Water Rights and Administration

(Continued from page 778)

as in the case of diffused surface waters. But this claim should be based upon a corresponding duty to his neighbors and others using water from the ground-water reservoir to see that the water is not wasted or polluted and the pressure unduly dissipated, and to manage waters and land within the farm boundaries and ground-water reservoir so as to maintain their capabilities over the years.

Soil conservation districts and other local agencies have the responsibility for helping to set local standards of ground-water development, use and management. These standards, once wisely established, could become part of local custom. They might then be incorporated into the body of law regarding water when widely accepted.

The state legislatures also have the responsibility to provide adequate authority to assure a satisfactory basis for cooperative and regulatory ground-water programs, especially where important investments are involved. Experience has told us that these programs should be carried out as nearly as possible upon a local basis, except where extremely critical problems exist and then the state must take control.

Here also is a major field in which the American Society of Agricultural Engineers can help to secure needed improvements. Progress can be expected to be slow at best, but it can be accelerated by education, understanding and participation of land users and professional groups in the consideration of these problems.

SUMMARY

It has been indicated that water problems having legal and administrative implications arise out of too little or too much water because of the limitations of time, place and amount of its occurrence. These limitations have become rather acute in certain localities of the nation during and since World War II, especially in the seaboard states.

It is evident that broad social and economic changes giving rise to these water problems also involve the soil conservation movement. Farmers play a very vital role as custodians of the water supplies and community watersheds of their respective areas, including both the *use* and *damage* aspects of water. Thus it is appropriate for farmers organized in soil conservation districts to give consideration to water problems having legal and administrative implications, and to work with other water-using groups who are dependent upon the same sources of supply, and professional societies whose members have technical advice to give. These matters involve principles of law as well as engineering and geology.

IMPROVEMENTS IN WATER LAW AND ADMINISTRATION

The points at which improvements in water law and administrative systems can be made seem to be: (1) legislation to provide for control of artificial rainmaking; (2) study of physical and legal principles involved in the management and use of diffused surface waters to meet varying topographic and land-use situations, following which legislation may be found desirable and practical; (3) legislation to provide for the orderly development, wise use, conservation and protection of stream and lake waters; and (4) legislation to provide for the orderly development, wise use, conservation and protection of ground waters. Legislation concerning group organizations for the development, management and use of surface and ground waters ought to be developed or improvement made in existing law in the course of the development of comprehensive water codes. Action on basic property rights ought to come first where possible.

At best, progress in certain of these fields of legislation is bound to be slow. People in the East have been used to following certain traditions and ways of doing things that are of long standing. It is perfectly natural for them not to be inclined to make rapid changes. Because of this situation, it would seem wise to move rather slowly — first, with respect to the establishment of sound water policies which laymen can readily understand[18]. Second, with respect to procedures and organizations for the implementation of these policies in each major field of water use and management, and, third, with respect to plans and programs for further implementation of those policies.

In each step, emphasis needs to be placed upon creating favorable attitudes of mind and understanding so that the responsible people concerned can come to accept new and better ways of doing things. Creating trust and confidence should be the basis for each step.

The leadership for making changes in all these matters should come from key people in each state, especially the water users, members of the legislatures, the governors, and heads of executive agencies and their advisers. Each state is a separate problem calling for special attention.

Water is at the heart of the economic development of every state. Water is the primary responsibility of the states and their land and water users. We should all recognize these fundamental considerations.

Agricultural engineers can play a very important role as advisers to water users and members of legislatures in helping them to improve their water laws and administrative systems. It is important that they play their full part so as to help in harmonizing engineering and legal principles.

[18]See joint resolution of the South Carolina General Assembly, March, 1953, wherein a new water policy was established and a new joint legislative-executive committee authorized to work out the details of how best to implement that policy.

Tractor Cranes Aid Stream Measurement

DURING the early 1930's, instrument makers mounted a boom on a trailer attached behind a truck. It was crude, but for gaging deep swift streams it saved a lot of time and manual labor — also it gave more accurate results.

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In the new arrangement, the crane (mounted on a small tractor) has a special boom which can be rotated through 360 deg and adjusted to practically any desired vertical angle by means of a manually operated fluid jack. An 8.4-in "hydrosheave drive" is mounted at the end of the rear power takeoff, and the necessary power for raising sounding weights up to the 300-lb size is transmitted to the reel through multiple V belts.—Briefed from "Field Hints" in *Civil Engineering* for October, 1953.

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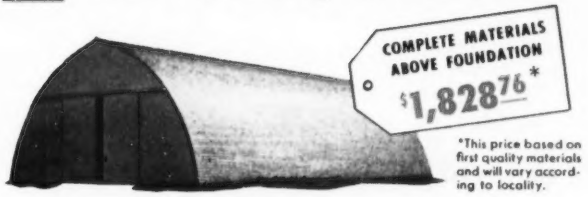

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Improvements in the L-Shaped Fence Staple

E. George Stern

SINCE the original, 1½-in long, 9-gage, L-shaped, threaded-shank, fence staple was brought to market, two developments have taken place. First, the diamond points of the original staple were changed to sheared points, to facilitate easier driving without loss in holding power. Second, a special hardened, L-shaped staple was developed for driving into such hardwoods as black locust, white oak, and hickory.

The standard staples with sheared points (Fig. 1) can be started easier than those with diamond points. They are equally effective as shown in diagrammatic form in Fig. 2. While the initial holding power of the L-shaped staples was 75 percent greater than the corresponding withdrawal resistance of the U-shaped staples, the 1, 3, 6, and 12-week delayed holding power of the L-shaped staples was 79, 78, 77, and 135 percent, respectively, greater.

In order to be able to use the L-shaped fence staple for fastening wire fences to posts made of such hardwoods as black locust, white oak, hickory, birch, and sugar maple, a hardened steel staple was designed for mass-production which can easily be driven into these posts without the bending troubles encountered when driving the U-shaped staple. This heat-treated and tempered, high-carbon-steel, L-shaped staple, shown in Fig. 1, can be driven satisfactorily where the U-shaped staple is extremely hard to drive, as shown in Fig. 3. The U-shaped staple buckled while being driven into the dry black locust post, while the L-shaped staple could be driven with forceful blows without bending or buckling.

The L-shaped staple, although made of less metal and weighing less than the U-shaped staple, holds equally well immediately after driving. Moreover, even a short time after driving, the new staple provides considerably more holding power, as is indicated in Fig. 4. With the expected loss in holding power of the U-shaped staple and the maintenance of holding power of the threaded L-shaped staple in the creosote-impregnated pine post, the threaded L-shaped staple can be expected to show even greater superiority as time passes.

The lack of drivability of the U-shaped staple into hard hardwoods resulted in a dislike of locust and hickory posts by many who had tried to drive the U-shaped staple into the posts. The easy drivability of the hardened L-shaped staple opens new fields in hardwood utilization.

Especially in the case of hickory, the availability of the improved staple allows the manufacture and economical use of square and round hickory fence posts. From the long-range hickory-utilization viewpoint, this single development may result in the desired use of a relatively large amount of hickory for this particular purpose.

Similarly, as a result of the easy drivability of the new fastener even into dry black locust, this decay-resistant hardwood may regain its own place as fence-post material after having been supplanted to a certain degree by creosote-pressure-treated pine.

The hardened L-shaped staple has been driven into many hard hardwoods. The results often were more than surprising especially in the light of the usual poor experience with the U-shaped staple.

This paper was prepared expressly for AGRICULTURAL ENGINEERING and is in sequence of the original paper, entitled "The L-Shaped Fence Staple," as published in AGRICULTURAL ENGINEERING (vol. 34, pp. 227-230, April, 1953). It is based on development work performed jointly by the Wood Research Laboratory of Virginia Polytechnic Institute and the Independent Nail & Packing Co., Bridgewater, Mass., manufacturer of the L-shaped fence staples.

The author—E. GEORGE STERN—is research professor of wood construction, Virginia Engineering Experiment Station, Virginia Polytechnic Institute.

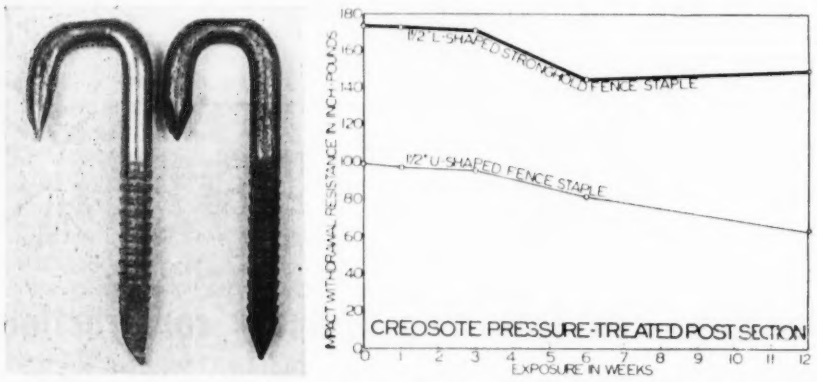

1½" L-SHAPED STRONGHOLD FENCE STAPLE
1½" U-SHAPED FENCE STAPLE
CREOSOTE PRESSURE-TREATED POST SECTION
IMPACT WITHDRAWAL RESISTANCE IN INCH-POUNDS
EXPOSURE IN WEEKS

Fig. 1 *(Left)* Standard (left) and hardened (right), 1½-in long, L-shaped fence staples with sheared and diamond points, respectively • Fig. 2 *(Right)* Effectiveness of fence staples with sheared points. Average, immediate and delayed, axial impact withdrawal resistance of 1½-in long, L-shaped fence staples and galvanized U-shaped fence staples immediately after driving into a creosote-pressure-treated section of southern pine post of 24 percent moisture content and after exposure for 1, 3, 6, and 12 weeks to 50 percent relative humidity at 70 F temperature

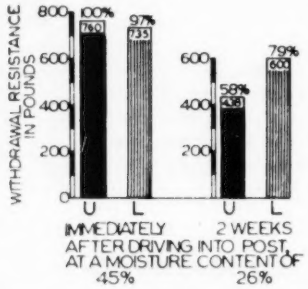
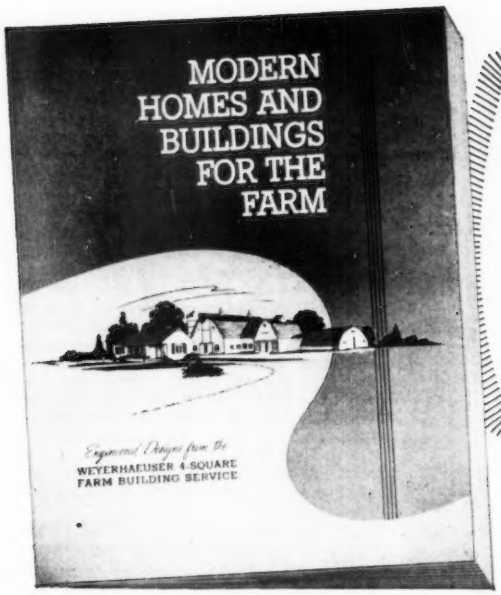


Fig. 3 *(Left)* Determination of drivability of hardened L-shaped fence staple and galvanized U-shaped fence staple into dry black locust. (Note deformed U-shaped staple in contrast to perfectly driven L-shaped staple) • Fig. 4 *(Right)* Effectiveness of U-shaped and of L-shaped fence staples. Average, immediate and delayed, axial withdrawal resistance, in pounds, of 1½-in long, 9-gage, galvanized U-shaped staple and hardened-steel, L-shaped staple (with diamond point) immediately and 2 weeks after driving into green black locust fence post of 0.71 specific gravity and 45 percent moisture content at 0.10 in per min rate of withdrawal



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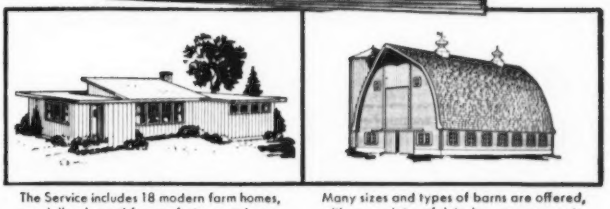

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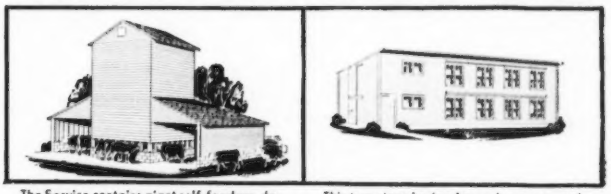

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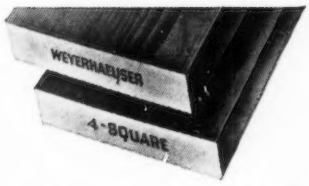

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NEWS SECTION

Worthington and Wood Elected Fellows of ASAE

THE constitution of the American Society of Agricultural Engineers provides that "a fellow shall be an engineer who shall have acknowledged engineering attainments, twenty years of active practice in the profession of engineering, and shall have ten years in the grade of Member. . . . The grade of Fellow shall have honorary status to which engineers of distinction may be elected but for which they may not apply." The By-laws of the Society also provide that "Nomination for Fellow shall be made to the Council by at least ten Fellows or Members of the Society, who shall state in writing the reasons for which the nomination is made."

W. H. Worthington

Ivan D. Wood

Recently two separate groups of Members and Fellows of ASAE placed in nomination for election to the grade of Fellow the names of Wayne H. Worthington, director of engineering research, John Deere Waterloo Tractor Works, and Ivan D. Wood, irrigation engineer, Soil Conservation Service, U.S. Department of Agriculture. Mr. Worthington's membership in ASAE dates back to 1921, and Mr. Wood's to 1919. Both men have achieved outstanding distinction in the agricultural engineering profession.

An engineering graduate of Oklahoma A. & M. College in 1910, Mr. Worthington was immediately employed by the J. I. Case Co. as a service engineer, and during the more than 40 years since he has achieved a notable engineering record in the farm tractor and machinery field. One of his contemporaries in this field recently said of him: "Wayne Worthington probably knows more about the development of modern farm equipment than any other engineer in this country."

Ivan D. Wood, one of the first half-dozen graduates from an agricultural engineering curriculum, early won distinction as an extension agricultural engineer; in fact, his whole career has been in helping the agricultural industry to apply engineering more economically and efficiently. In recognition of his achievements, ASAE awarded him the John Deere Gold Medal in 1952 and he was president of ASAE in 1952-53.

Lee Ford Heads Chicago Section

LEE H. FORD was elected and installed as the new chairman of the Chicago Section of the American Society of Agricultural Engineers at its meeting Monday evening, October 19.

Three vice-chairmen were also elected as follows: Kenneth W. Snyder, vice-chairman for publicity; Anthony W. Bakken, vice-chairman in charge of meetings, and Donald A. Womeldorff, vice-chairman in charge of outside activities. Erwin R. Johnson was elected the new secretary-treasurer. C. L. Hamilton, J. H. Wessman, and Frank J. Zink were elected to the nominating committee.

George D. Scarseth, director of research, American Farm Research Association, Lafayette, Ind., was the speaker of the evening. In his talk on new cultural practices for corn he reported outstanding success with the use of crop residues and heavy applications of commercial fertilizer to increase yields per acre and to improve the productive capacity of land on which corn is grown continuously over a long period.

ASAE Meetings Calendar

November 20 — OKLAHOMA SECTION, Student Union Building, Oklahoma A. & M. College, Stillwater

December 7-9 — WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

January 22 and 23 — PACIFIC COAST SECTION, Stockton, Calif.

February 1-3—SOUTHEAST and SOUTHWEST SECTIONS, Baker Hotel, Dallas, Tex.

April 2 and 3 — ROCKY MOUNTAIN SECTION, Colorado A. and M. College, Fort Collins

June 20-23—47TH ANNUAL MEETING, University of Minnesota, Minneapolis

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Alabama Section Honors Pap Easter

HURRICANE Florence failed to dampen the enthusiasm of members of the Alabama Section of the American Society of Agricultural Engineers, who met at Gulf Shores, Ala., on the Gulf of Mexico, September 25; in fact, it seemed to respect the defiance shown by the group to repeated hurricane warnings and changed her course at the last minute merely brushing Gulf Shores with her skirttails.

Meanwhile Alabama Section members and guests, 51 strong, were treated to a historical program presented by those who were responsible for the early development of agricultural engineering in Alabama.

T. B. Chambers and A. Carnes, sales engineers from the Spartanburg, S.C., division office, told how the Soil Conservation Service was begun and how it developed the extensive program now in operation. E. C. Easter, vice-president of the Alabama Power Company, reviewed the growth of rural electrification in Alabama beginning with the first rural home in the state to be served by electricity. R. C. Fergason, chief engineer, Gadsden, Ala., works of the Allis-Chalmers Mfg. Co., showed a movie, titled "Cotton Grows Up," giving the story of the development of cotton production and harvesting machinery and its meaning to the cotton-producing areas.

M. L. Nichols, director of the USDA Tillage Machinery Laboratory at Auburn, brought all these and other phases of agricultural engineering together in describing the history of the growth of agricultural engineering in Alabama. Copies of these talks are to be kept in a permanent file as their historical value is highly treasured by agricultural engineers in the state.

An outstanding address at the evening banquet by L. C. LeBron, of the Hercules Powder Company, formerly an Alabama agricultural engineer, was a fitting climax to the afternoon program. It served also as a buildup to the presentation to E. C. (Pap) Easter of a "certificate of appreciation" for his interest and leadership in the activities of the Alabama Section. J. B. Wilson, another pioneer in Alabama agricultural engineering, made the presentation.

Ohio Section Fall Meeting

IN ALL but the outcome of the attendant football game, the ASAE Ohio Section held a successful meeting at Ohio State University, Saturday, October 10. The meeting was held in Ives Hall, the agricultural engineering building.

Henry N. Luebcke, chairman of the Section, called the meeting to order promptly at 10:00 a.m. and presented a report of the preceding meeting while a few latecomers were still arriving. He then turned the meeting over to Cernyw K. Kline who represented the program committee in the absence of Bruce K. Tice, chairman, who was delayed enroute to the meeting.

Mr. Kline introduced first E. C. Leitz of the Spaulding Fiber Co., who talked on the manufacture, properties and farm equipment

(News continued on page 786)

Agricultural engineering "old timers" in attendance at the ASAE Alabama Section meeting on September 25. Left to right, J. B. Wilson, who presented the certificate of appreciation; E. C. (Pap) Easter, recipient of the certificate; T. B. Chambers, M. L. Nichols, L. C. LeBron, A. Carnes

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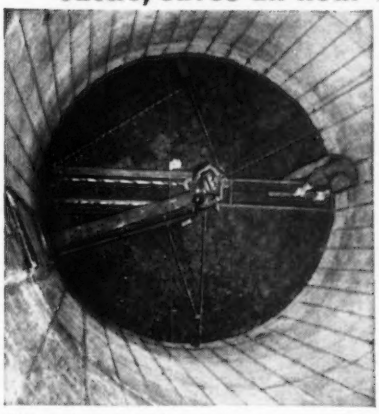


Above photo shows how unloader keeps walls perfectly clean . . . silage smooth and level.

Mr. Jacox just presses a button and silage pours out in perfect feeding condition.

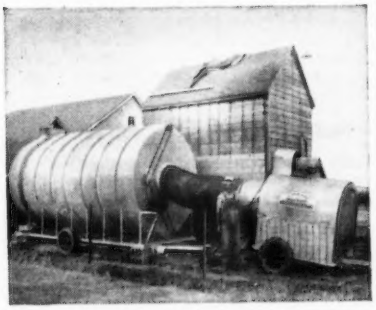
Mr. Ralph Jacox of DeKalb, Illinois finds that his silo unloader gives him all the feed he needs for his cattle quickly and efficiently . . . plus giving him extra time for other chores. Says Mr. Jacox, "My silo unloader chops my silage fine and saves me about one hour a day in my feeding chores. The unloader throws down in 20 minutes enough grass silage to feed my 100 feeder cattle."

Throwing down silage is hazardous, heavy work, particularly grass silage, and especially if it's frozen. But with an unloader, no matter how hard packed or frozen the silage is, it still comes out quickly and as fine as it was when it was blown into the silo. Furthermore, the food value is increased since the silage is delivered to cattle thoroughly aerated and without chunks or lumps. This eliminates costly waste feed, too.

The unloader has few parts, assuring maximum use. Operation is simple yet effective . . . silo walls are kept clean and the silage surface smooth and level. The unloader operates in any out-of-round silos. It is powered with a dependable G-E motor. For more information, check silo unloader on coupon.

"PUSH BUTTON" DRYING FOR 70,000 BUSHELS OF CORN

Dryer also makes early harvest possible, preserves top quality



Mr. Campe and his labor saving grain dryer.

Mr. Rollo Campe, Route 2, Fairmont, Minnesota has found it no trouble at all to dry over 70,000 bushels of shelled corn with his automatic crop dryer. Furthermore, the Dryer enables Mr. Campe to do his harvesting earlier when the corn is at its best. Says Mr. Campe:

"I like my drying system because I can harvest my corn at an earlier date when it's at its best. Then I can preserve this quality by removing the moisture, and the corn is safe for storage over a long period of time in accordance with the present corn storage program. The dryer does a very satisfactory job on my whole crop, and the push button operation of the equipment makes all my work simple and easy."

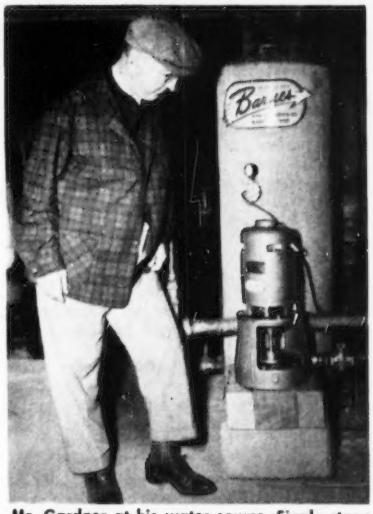
Mr. Campe's Dryer is powered by a dependable G-E motor. For more information on how to put a similar unit to work on your farm, check "Crop Dryer" on the coupon on the right.

AUTOMATIC WATER SYSTEM FOR LIVESTOCK AND GARDEN FREES OHIO FARMER FOR OTHER CHORES

Mr. R. B. Gardner of Mansfield, Ohio uses fresh water in his scientific feeding program for livestock, and also for irrigating his garden. By using an automatic pumping system, he always has fresh water before his livestock, and keeps his garden well irrigated, while he is left free to do other work. Says Mr. Gardner:

"In my program of feeding both beef and hogs, there is drinking water in front of my livestock at all times. Water is the cheapest feed I can give them, and with running water piped right to stock tanks and waterers, there is no tendency on anyone's part to skimp on water or forget to keep the tanks filled. As for my garden, automatic irrigation saves me time and trouble, and gives me better results, too. It costs only a few cents a day to run my pump, and I don't see why anyone would pump and carry water by hand when they can get the same job done automatically."

Mr. Gardner's water comes from a 40-foot lift, deep well pump powered with a dependable G-E 1½-hp motor. For more information, check "Water Systems" on coupon.



Mr. Gardner at his water source. Single stage pump has 1720 gal. per hour capacity.

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NEWS SECTION

(Continued from page 784)

applications of fiber and fiber-phenolic laminated materials. His talk was illustrated by slides.

J. D. Hummell, research engineer, was the second speaker. He reported informally on some tests of alcohol-water injection for farm tractors, which resulted in an increase in power output of definite interest to the cooperating farmers.

In a brief business meeting at the close of the session, consideration was given to the possibility of having one or more two-day meetings of the Section during the year. Following the discussion, members present were asked to indicate their preference on a ballot sheet to be turned in at the close of the session.

Chairman Luebcke also asked the members to turn in names of prospective members, together with the names of appropriate member sponsors who might most effectively add a personal touch to formal invitations to apply for membership.

Discussion of the desirability of inviting the Society to hold another annual meeting in Ohio at the first opportunity resulted in the appointment of G. W. McCuen to work with the Columbus Chamber of Commerce in preparing a summary of facilities and attractions to be offered in support of an official invitation from the Section to the ASAE Council.

A number of the members were accompanied by their families at the luncheon following the morning session. Robert McMasters of Battelle Memorial Institute gave an entertaining and informative illustrated talk, entitled "Be Your Own Weatherman." Following the luncheon most of the members became a part of the capacity crowd which saw their favorite Ohio State football team upset by the University of Illinois.

Ground Broken for New A-E Building at Cornell

ON SEPTEMBER 26 ground was broken for the new agricultural engineering building on the campus of Cornell University at Ithaca, N. Y., according to word received from Orval C. French, head of the department.

Complete construction contracts total more than $2,000,000. This does not include equipment for the building, which it is estimated will amount to $300,000. Completion date is scheduled for the fall of 1955. The building will have in excess of 100,000 square feet of floor area and a volume of 1½ million cubic feet.

Farm Drainage Conference

THE 9th annual drainage conference sponsored by the Mason City Brick and Tile Company, will be held November 23 and 24 at the Hanford Hotel, Mason City, Iowa. The company extends a cordial invitation to all interested in any way in the drainage of farm lands to attend this conference. The program this year will include procedure in figuring cost of digging a tile ditch, to include such costs as insurance, depreciation, investment, spare parts, etc. Other program features include a resume of fundamentals of drainage, how it improves field conditions, and an illustrated lecture on drainage and local conditions in Iran. There will also be illustrated lectures on machinery and drainage equipment and a display of trenching machines.

Department Head Change at Connecticut

MERLE S. KLINCK retired October 1 as head of the agricultural engineering department at the University of Connecticut. He has served in that capacity for the past 25 years. He will continue work in resident teaching in the department, and in "extracurricular" activities.

W. C. Wheeler is the new head of the department. For the past several years he has been a member of the agricultural engineering department at the University of Tennessee.

Grassland Farming Meeting

THE Joint Committee on Grassland Farming has announced the program for its annual national meeting, to be held this year at Dallas, Texas, November 15 and 16, preceding and in conjunction with the annual meeting of the American Society of Agronomy.

Visits to Rough Creek Ranch at Chalk Mountain and Flat Top Ranch at Walnut Springs are scheduled for Sunday, Nov. 15.

Monday forenoon, November 16, C. N. Shepardson, dean of agriculture, A. & M. College of Texas, is to preside over a session featuring presentations on maintaining high-quality ranges, by B. W. Allred, Soil Conservation Service, USDA; making improved grasses and legumes available for southwestern agriculture, by A. P. Atkins, Oklahoma Pasture Seed Growers Ass'n.; the part agricultural research can play in the southwest, by Harold Vogtborg, Southwestern Research Institute, and permanent agriculture in the Southwest, by Howard B. Sprague, Pennsylvania Agricultural Experiment Station.

R. D. Lewis, director, Texas Agricultural Experiment Station, will be chairman for the afternoon session offering papers on climate and fertilizer in relation to high protein forage for the Southwest, by Horace J. Harper, Samuel Roberts Noble Foundation; promising new developments in southwestern livestock agriculture, by Henry Biederman, editor, *The Cattleman;* suggestions for increasing range forage and livestock production, by David A. Savage, Southern Plains Field Station, USDA; and future of irrigation on pastures in the Southwest, by M. L. Peterson, University of California.

The Southwest—Past, Present, and Future, an illustrated talk by G. T. Harley, International Minerals and Chemical Corp., is to be presented at an evening session with Thomas C. Longnecker, Texas Research Foundation, presiding.

The American Society of Agricultural Engineers is one of 19 cooperating member organizations with representatives on the Joint Committee; W. C. Krueger, who represented ASAE at Committee's organization meeting in 1944, is its current representative. In addition some 20 or 30 other ASAE members are individual members of the Joint Committee or representatives on it for other professional, industrial, educational, research, governmental and publishing organizations.

Last year the annual meeting of the Joint Committee was held in conjunction with the ASAE winter meeting at Chicago in December. When the Committee was organized, it was decided that it would be "devoted to research in the production, methods, equipment, facilities, preservation and utilization of forage crops, and adopted objectives looking to further encouragement of research, practice, and public information on grassland farming."

FEI Power Machinery Department Meeting

THE Farm Equipment Institute announces that the fall meeting of its Power Machinery Department will be held November 20 in the Gold Room of the Congress Hotel, Chicago. The meeting opens at 9:45 a.m. with a panel discussion of the dealers' retail salesmen, the moderator for which will be C. G. Pearse, vice-president, J. I. Case Co. Other topics for the forenoon session will be conservation as a sales tool, the industry's interest in coordinated research, and foreign trade developments.

The afternoon session will open with a talk by W. D. Knox, editor, *Hoard's Dairyman,* on a self-help program for the dairyman, and he will be followed by Paul C. Johnson, editor, *Prairie Farmer,* whose subject is "A Look at the Outlook." These two talks will be followed by an open forum on the industry outlook, at which Bruce Lourie, vice-president, Deere and Company, and chairman of the FEI Executive Committee, will be the discussion leader.

Sprinkler Irrigation Convention

THE Sprinkler Irrigation Association will hold its sixth annual convention at the del Coronado Hotel, Coronado Beach, Calif., on December 1 to 3, according to announcement by Association President Marion Miller. All sessions of the convention, except the strictly business sessions, will be open to friends of the sprinkler irrigation industry as well as members of the Association.

Following are some of the questions that will be on the agenda for discussion at the convention: Shall the industry promote a standard warranty guaranteeing that sprinkler installations meet the ASAE recommendation for design, installation and performance? Shall the Association and the Soil Conservation Service jointly sponsor training schools for distributors, dealers, college professors and personnel of the SCS and the USDI Bureau of Reclamation? Requests for hotel reservations in connection with the convention should be addressed to Clem Laufenberg, Berkeley Pump Co., 829 Bancroft Way, Berkeley, Calif.

Hawaii Section Soils Program

SOIL and organic material problems in Hawaiian agriculture were featured in a technical meeting of the Hawaii Section, ASAE, on August 18, at the University of Hawaii.

The first speaker was A. C. Trouse, Jr., Hawaiian Sugar Planters Association, who reported on work being done by Roger P. Humbert and associates in the agronomy department of the Association, on soil improvement with organic materials. He also showed a colored motion picture of methods used to incorporate organic matter in the soil at Kekaha Plantation.

Hawaii Section Chairman Warren Gibson spoke next on field and machinery problems in handling and incorporating organic materials in the soil. He reported on an experiment in progress at Ewa Plantation which indicates that the operation will pay off in increased sugar yields, even with present high cost methods of adding organic matter.

K. F. Manke, Hawaiian Pineapple Co., talked on the use of organic materials in pineapple production.

Lloyd E. Blomquist, California Packing Corp., speaking on machinery used in handling and incorporating organic materials in the soil, explained the mulch-tillage machine being used by that organization.

(News continued on page 788)

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

ABRAHAMS, JOHN HENRY, JR.—Soil scientist, Texas Research Foundation, Renner, Tex. (Mail) Box 5

ANDRZEJEWSKI, OSVALDO—Chief, Agricultural Mechanization Service, State of Parana, Brasil. (Mail) Rua: Celestino Junior 366 – Curitiba

EVANS, OWEN H. — Agricultural engineer, Green Giant Co., Beaver Dam, Wis. (Mail) 212 Grove St.

FISKE, KENNETH V. D.—Owner and general manager, Fiske Farm Advisory Service, RR 3, Woodstock, Ill.

FLYNN, REGINALD J.—Agronomist, Department of Agriculture. (Mail) 254 Ryan St., South Grafton, New South Wales

GREENE, GARY Y.—Instructor, agricultural engineering department, University of Tennessee, Knoxville, Tenn.

KERMAN, ROBERT E.—Sales and engineering service, Bower Roller Bearing Co. (Mail) 9321 N. Tennyson Drive, Milwaukee 11, Wis.

LAYER, JOHN W.—District agricultural engineer, New York State College of Agriculture. (Mail) 44 East 14th St., Huntington Station, N. Y.

LUDWIG, HOWARD W. — Sales engineer, Bower Roller Bearing Co. (Mail) 2542 29th Ave. Court, Moline, Ill.

LYLE, REX T.—Wheat farmer, Cunningham, Wash.

MILLIKEN, FRANK H.—Manager, The Bowerston Shale Co., Bowerston, Ohio

PETERSON, DEAN F., JR.—Head, civil engineering dept., Colorado A & M College, Ft. Collins, Colo. (Mail) 1342 W. Oak St.

POND, JUDSON S.—Sales trainee, Deere & Webber Co. (Mail) 1311 N. Cleveland Ave., St. Paul 8, Minn.

SALO, GLENN W.—Instructor, University of Idaho, Moscow, Ida. (Mail) 1120 Deakin St.

SAUDER, MAX L. — Power use director, Southeast Colorado Power Assn., 901 West 3rd St., La Junta, Colo.

SPENCER, ROGER L.—Ground electronics officer, U.S. Air Force. (Mail) Waveland, Indiana

WEBB, REX A.—Engineer in training, Indiana Highway Commission. (Mail) RR 2, Gosport, Ind.

WEDGWORTH, GEORGE H.—Vice-president, Wedgworth's, Inc., PO Box 648, Belle Glade, Fla.

WILSON, CHARLES W. — Assistant chief, motor vehicle research div., Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.

TRANSFER OF MEMBERSHIP GRADE

CALVERT, W. A., JR.—Farm Institute representative, Reynolds Metals Co. (Mail) 2228 W. Market St., York, Pa. (Associate Member to Member)

SHELLEY, W. G.—General manager, O. W. Kromer Co. (Mail) RR 2, Wayzata, Minn. (Associate Member to Member)

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NEWS OF ASAE MEMBERS

William A. Bailey recently joined the organization of the Niagara Chemical Division, Food Machinery and Chemical Corporation, Middleport, N.Y. He was formerly on the technical staff of the USDA Cotton Ginning Laboratory at Leland, Miss.

Ned J. Bond, Jr., is now with the Louisiana State Rice Milling Co., at Abbeville, La. He was formerly engineer and partner in the J. E. Reeser Co., Maroa, Ill.

Leon F. Charity, until recently instructor in agricultural engineering at the University of Minnesota, is now a research assistant in the agricultural department of Cornell University at Ithaca, N. Y.

Andrew M. Cowan, Jr., a recent graduate in agricultural engineering, is now employed as a graduate assistant in farm machinery in the agricultural engineering department, Iowa State College, Ames.

George W. Curtis, for many years manager of the Milwaukee division of The Timken Roller Bearing Co., recently retired from his position with the Company, and is now located at Ft. Myers, Florida, where he will engage in a manufacturing business.

Benjamin F. Detroy, who has been serving as an agricultural engineer in the agricultural engineering divisions, U.S. Department of Agriculture, stationed at Leland, Miss., is now a product test engineer at the East Moline Works of the International Harvester Co., East Moline, Ill.

Robert E. Doughty has received appointment as assistant professor in the agricultural engineering department at the University of Florida, Gainesville. Since obtaining his B.S. degree in agricultural engineering at the University of California in 1950 and his M.S. degree at Oregon State College in 1952, he has since been employed in a dual position as mechanical design engineer in a West Coast navy yard and as instructor in basic engineering at Olympic College.

Jeff E. Flanagan, until recently employed as an agricultural engineer with the Office of Foreign Agricultural Relations, U.S. Department of Agriculture, and stationed in El Salvador, resigned recently to accept a position with Michael Baker, Jr., a firm of consulting engineers at Rochester, Pa. His first assignment in his new position will be that of assistant chief design engineer for the Yarmouk-Jordan Valley Irrigation Project in Jordan.

J. K. Garner, who has for some time been serving the FAO mission in Pakistan, as farm machinery specialist in the agricultural division of the Ministry of Food and Agriculture, was appointed some time ago as chief of the mission.

John M. Goodman, who has been serving in the capacity of agricultural engineer with the South Carolina Electric and Gas Co. at Johnston, S. C., was recently transferred to the company's office at Denmark, S. C., where he is now manager of the company's rural development division.

Robert L. Green, who for the past two years has been serving as an agricultural engineer on a TCA mission in Indonesia, has completed his assignment with that organization and resumed his position of assistant professor of agricultural engineering at Louisiana State University. He has also completed all requirements for his PhD degree in agricultural engineering, which is to be awarded him by Michigan State College.

John M. Johnson, formerly extension agricultural engineer, University of Florida, is now manager of the agricultural engineering division of the Moore Dry Kiln Co., Jacksonville, Fla. At the organization meeting of the Florida Section of ASAE in May of this year, he was elected the first secretary of the Section.

Vaughn C. Kegg has been made general manager of the Ohio Grease Co. at Loudonville, Ohio, having resigned as a buyer for United Cooperatives, Inc., Alliance, Ohio.

David A. Milligan recently accepted appointment as vice-president in charge of sales of the American Tractor Corp., Churubusco, Ind., having resigned as domestic sales manager of Harry Ferguson, Inc. In addition to several years experience in the wheel tractor field, Mr. Milligan has had twelve years' experience in the development and manufacture of track-type tractors and industrial equipment. He has traveled the United States and Canada extensively in consulting and estimating earth moving, logging and other operations requiring track-type tractors. He was a consultant to the U.S. Bureau of Public Roads in the selection of equipment for the Pan-American Highway prior to World War II.

D. A. Milligan

Charles M. Noble, a 1952 agricultural engineering graduate, who has been on duty with the U.S. Army at the Army chemical center in Maryland, has recently been separated from active duty with the Army and has accepted employment with the Chrysler Corporation and is enrolled in the Chrysler Graduate Institute. He is located at 69 Winona, Highland Park 3, Mich.

Robert B. Skromme, employed as a design engineer of the J. I. Case Co., was recently transferred from the Rockford Works to the Bettendorf Works of the Company at Bettendorf, Iowa.

C. Togo Sturdivant, who has been serving as agricultural engineer for the Institute of Inter-American Affairs at Lima, Peru, has been transferred to LaPaz, Bolivia.

Herman F. Williams recently was named head of the agricultural engineering department at Arkansas State College. He was previously a member of the agricultural engineering staff at the University of Missouri.

John W. Zahradnik, agricultural engineer, Near East Foundation, who has seen two years of service with the foundation at Tehran, Iran, has returned to the United States for a short visit and will return to Iran in October. In that country he has been assisting the Foundation's program of technical improvement for the Iranian peasant. Among the projects in which he has taken part were demonstrations of soil preparation, village water supplies, improved granaries, and a traveling work shop to service the plows and tractors being introduced by the Point IV Program and the Foundation.

NEW BULLETINS

Small Farm Implements, by H. J. Hopfen and E. Biesalski, FAO Development Paper No. 32 (June, 1953). Food and Agriculture Organization of the United Nations (Rome, Italy). Brief information on some elementary man, woman and animal-power tools which represent improvements over types currently in use in some parts of the world. For engineers in the United States it will provide an effective reminder that the agriculture in some areas of the world is still in the early iron age era of mechanization. It presents generally sound applications of physical principles and such basic machine elements as the lever and wheel, for the use of human and animal power where economic and social conditions dictate their use as a practical necessity. The text indicates that for long-distance carrying, the load to be carried by a woman should not exceed 33 pounds.

Economic and Social Aspects of Farm Mechanization in Turkey. University of Ankara. This is a comprehensive report on the subject, based on a study financed by MSA funds. It covers changes in agricultural techniques associated with mechanization, mechanization and changes in type of farming, technical problems of mechanized agriculture, economic problems, and social and legal problems created by mechanization.

Choosing Equipment for the Farm, by Irving F. Fellows. Bulletin 440 (June 1953) Connecticut Agricultural Extension Service (Storrs). An approach to equipment selection from the standpoint of economics, discussing briefly the increasing use of farm equipment, economic principles, costs, returns, balance, and budgeting.

1953 Cotton Ginner's Handbook. Compiled by Tom J. Johnston. Delta Council of Mississippi, and Mississippi Agricultural Extension Service (State College). A current condensed guide to ginning practice, covering effect of ginning on cotton quality, needs and problems of the ginner, the cotton drier, cleaning and extracting, gin stand operation, the lint cleaner; lint flue, condenser, tramper and press; seed handling systems, and fans and piping.

Report of the Agricultural Aviation Research Conference (Feb. 25-26, 1953) Agricultural Research Administration, U. S. Department of Agriculture (Washington 25, D.C.). The conference reported was sponsored by the Agricultural Research Administration, with the cooperation of the Texas Agricultural and Mechanical College. It is reported under the main headings of conference notes, recommendations for additional research, statements of participants, and miscellaneous information presented at the conference.

Evapotranspiration: Excerpts from Selected References, compiled by Howard W. Lull. Occasional Paper 131 (August, 1953), Southern Forest Experiment Station (New Orleans), U. S. Department of Agriculture. Seventy-six references to the works of more than 80 authors are cited and commented on under the headings of general discussion, evaporation, transpiration, evapotranspiration, roots and soil moisture, and roots.

Harvesting Machinery for Hay and Silage, by Wm. Kalbfleisch and A. I. Magee. Experimental Farms Service, Department of Agriculture (Ottawa, Canada) Publication 885 (July, 1953). A users guide to equipment and methods for cutting, raking, cocking, tripoding, collecting, hauling, and storage. It includes information on auxiliary equipment, silos and silage, and factors used to compute annual cost of operating machinery.

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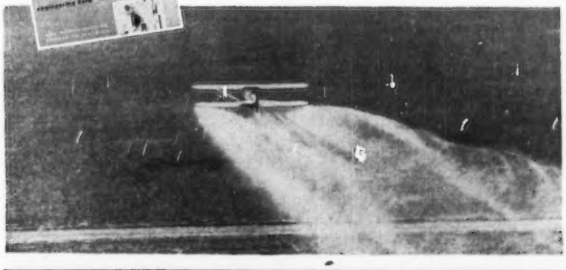


STOW MANUFACTURING CO.
39 SHEAR ST. BINGHAMTON, N.Y.

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—JUNE—O-147-524. JULY—O-254-526, 255-527. SEPTEMBER—O-301-530, 331-532. OCTOBER—O-348-534, 344-536, 361-537.

POSITIONS WANTED—MAY—W-193-31, 196-32. JUNE—W-204-34, 200-36, 203-37, 220-40. JULY—W-260-42, 266-43. AUGUST—W-269-44, 248-45, 272-46, 278-49, 292-50, 294-52. SEPTEMBER—W-306-53, 321-54, 339-56. OCTOBER—W-333-57, 357-58, 359-59.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER for product engineering work in farm structures field with metal products fabricator expanding service to the farm market. Midwest location. Engineering training including design, drafting and specialization in farm structures. No experience required. Pleasing personality. Age about 25. Good starting opportunity with growing organization which promotes from within the company. Salary $375 per mo. O-341-538

AGRICULTURAL ENGINEER for design and development work with established manufacturer located in a rural area in the East. BS deg in agricultural engineering, or equivalent. Farm background preferred. Some experience in farm machine design and development. Good health and ability to work with factory, office, and farm personnel. Good opportunity for advancement. Salary open. O-387-539

AGRICULTURAL ENGINEER (assistant professor) for suitable combination of teaching, research, and extension work, according to interests, in an eastern land grant university. BS deg in agricultural engineering, or equivalent. MS deg desirable. Experience in agricultural engineering teaching, research, or extension work. Able to meet and work with people. Age 25-35. Excellent opportunities for advancement in small school and department with no set tenure or salary schedules to hold down a man with ability. Usual retirement, hospitalization, and insurance benefits. Salary open. O-384-540

JUNIOR AGRICULTURAL ENGINEER for research, design, and sales engineering on new aluminum irrigation systems, including soil and water relationship studies with farmers using sprinkler equipment. BS deg or higher in agricultural engineering, soils or soil chemistry. Practical experience in research, design, and sales of sprinkler irrigation equipment or similar line, plus farm experience and soil chemistry or bio-chemistry work desirable. Keen interest in relation between soils and human nutrition and desire to serve mankind, combined with pleasant disposition, ability to meet people, and capacity for honest straightforward dealings with trade. Excellent opportunity for advancement with small, progressive organization pioneering revolutionary type of engineering and application of portable sprinkler irrigation equipment. Salary open, depends on effort and growth of business.

NEW POSITIONS WANTED

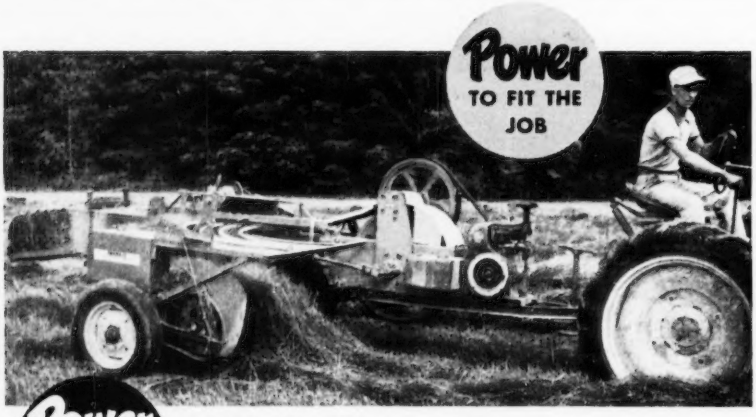
AGRICULTURAL ENGINEER interested in design, development, research, sales, or service in soil and water field or combination of technical branches, with industry in Southwest or West. Willing to travel part time. BS deg in agricultural engineering 1951, New Mexico College of Agriculture. Irrigated farm background. Agricultural engineering work in soil and water field since February 1951. Civil Service rating GS-7. Single. Age 25. Slight weakness in lower legs due to polio. Available on 20-day notice. Salary open. W-329-60

AGRICULTURAL ENGINEER interested in sales, sales promotion, or writing in farm structures or rural electric field with industry. Any location. Willing to travel part time. BS deg in agricultural engineering, 1948, Pennsylvania State College. Rural representative with electric utility nearly 3 yr. College teaching in rural electrification one year. With farm building equipment manufacturer 2 yr, in charge of design and promotion of crop drier now in production. Additional promotional work with universities. War cadet and commissioned service in Air Force. Married. Age 31. No disability. Available on 30 to 45-day notice. Salary open. W-351-61

AGRICULTURAL WRITER and public relations specialist interested in new location, preferably with industry in metropolitan area. BS deg, 1929, Northwestern University. MA deg 1933, George Washington University. Certified candidate for PhD in economic history, Columbia University. Writing and public relations experience 23 yr. War commissioned service in Navy 17 mo. Married. Age 44. No disability. Available on 2 weeks' notice. Salary $10,000. W-356-62

AGRICULTURAL ENGINEER interested in design, development, research, sales, service, or writing, with manufacturer, distributor or trade association in power and machinery or rural

(Continued on page 792)



Power TO FIT THE MACHINE

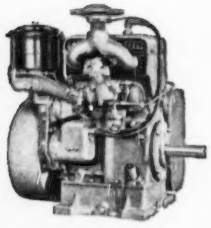
All Baling Operations Under the Driver's Eye

WISCONSIN-POWERED Roanoke Baler

Full-vision from the tractor seat is only one of the outstanding advantages of the Roanoke Junior Automatic Baler. According to the builders, Harrington Mfg. Co., Lewiston, N. C., this baler is ideally adapted to service both on small and large farms, flat or hilly. Its Five-Star features include Low Price, Light Weight, Narrow Width, Economical Operation and Gentle Handling of Hay.

In addition, it is equipped with a 2-cylinder Wisconsin Heavy-Duty Air-Cooled Engine . . . the most dependable power unit that money can buy for this type of equipment. Wisconsin features include thrust-absorbing tapered roller bearings at both ends of the crankshaft, high tension rotary type gear-drive magneto mounted on the *outside*, efficient AIR-COOLING under all weather conditions, positive lubrication and easy starting.

Write for your copy of the new 64-page Wisconsin Engine catalog, showing more than 260 original equipment service applications, many of which are in the farm field. Also contains specifications covering the full line of Wisconsin single cylinder, 2- and 4-cylinder models, 3 to 36 hp.



Wisconsin Model TE 2-cylinder Engine, used on Roanoke Junior Baler.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
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Professional Directory

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SEND TODAY for your free copy. Lists 34 use-tested plans for long-lasting Exterior plywood farm service buildings available from leading agricultural schools, Midwest Plan Service, Douglas Fir Plywood Association. Each listing includes illustration and detailed description. For free copy, write Douglas Fir Plywood Association, Tacoma 2, Washington.

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DOUGLAS FIR **Plywood**
For All Farm Service Buildings

EXT-DFPA

THIS BRAND MEANS WATERPROOF GLUE

Agricultural Engineers' YEARBOOK

The first edition of an ASAE-sponsored yearbook, announced in the 1952-53 Annual Report of the Secretary, will be published and distributed to ASAE members early in 1954. It will be known as the AGRICULTURAL ENGINEERS' YEARBOOK, and each member will receive one copy without charge. It will be on sale to non-members at a price of $5.00 per copy.

The Yearbook will contain a wide variety of information, for which ASAE members have frequent need. The main features will include (1) a roster of ASAE officers, divisions, sections, committees, and individual members; (2) the constitution, by-laws and rules of the Society; (3) standards, recommendations, and engineering data officially adopted or endorsed by the Society, and (4) a directory of manufactured products that agricultural engineers will find helpful in their various fields of activity.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

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Improved driver-comfort is one of today's major engineering objectives . . . and Milsco can help you to step up the man-work-factor of your equipment with job-fitted cushion seating. Milsco Cushion Seats are the developments of years of experience in designing and manufacturing heavy duty cushion seats for all types of mobile equipment. Our field studies of enduring cushioning materials and contour body support may prove of important value to you. Write us about your seating problem now.

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MILSCO MANUFACTURING CO.
2732 N. 33rd ST., MILWAUKEE 45, WIS.

Personnel Service Bulletin

(Continued from page 790)

electric field, preferably in New England area. Trained 3 yr at Cornell University, College of Agriculture, 1941-43. Farm background. Managed chemical fertilizer plant 2 yr. Farm representative for electric utility 8 yr, including personal contact work with farmers and farm groups, organization of Electric Council, work on new equipment and methods for area, especially in hay drying, pasture irrigation, barn ventilation, and materials handling. Married. Age 32. No disability. Available now. Salary $6500. W-368-63

AGRICULTURAL ENGINEER interested in teaching or research in farm structures or soil and water field with public service agency, any location. BS deg with honor in agricultural engineering 1947, Kansas State College. MS deg in agricultural engineering 1949, Oregon State College. Architectural draftsman 5 mo. Assistant to manager of state farmers cooperative association, 7 mo. Extension rural housing specialist 5 yr. War commissioned service 4 yr in antiaircraft artillery. Married. Age 33. Available on reasonable notice. Salary $5500. W-367-64

AGRICULTURAL ENGINEER interested in design, development, or research in soil and water field with industry or public service in South, Southwest or West. Prefer moderate travel. BS and MS deg, 1951 and '52, Ohio State University. Experience 2 yr as civil engineer; 3 yr as tool designer; 4 mo as soil mechanic; 8 mo as research soil scientist (present position). Limited farm experience. Married. Age 30. No disability. Available Jan. 1. Salary $5000. W-388-65

AGRICULTURAL ENGINEER interested in design, development, or research in power and machinery with manufacturer or consultant. Midwest location. Graduate aeronautical engineer, Curtiss-Wright Tech—1938. Tool design in aircraft industry 4 yr. Teaching, one year. Design and supervision with farm equipment manufacturer 11 yr, with promotions to chief design engineer supervising all new design and development. Married. Age 36. No disability. Available now. Salary $7000. W-369-66

AGRICULTURAL ENGINEER interested in engineering or agricultural development, service, teaching, writing, or part-time writing in power and machinery or soil and water field with industry, in Southwest. BS deg in agricultural engineering, 1949, A & M College of Texas. Pregraduation experience with Texas Agricultural Experiment Station and California Packing Corp. Cartographic aide. Veterans vocational school teaching, 4 mo. State board of water engineers, 44 mo. Married. Age 26. No disability. Available on 10 days' notice. Salary $5000. W-391-67

AGRICULTURAL ENGINEER interested in design, development, research, or writing in power and machinery field with manufacturer, consultant, or farming operation. Any location. Willing to travel. BS deg in agricultural engineering, 1953, South Dakota State College. Farm background. Worked in implement business while attending college. Farm equipment sales work since graduation. Married. Age 22. Two artificial limbs, no handicap. Available now. Salary open. W-382-68

AGRICULTURAL COLLEGE GRADUATE interested in design, development, research, sales, service or management in power and machinery or product processing field with industry or public service in the Southeast or South. Will travel. BS deg in agriculture expected February 1954. Overseer of cattle farm (500 head) over 4 yr. Wholesale sales of agricultural chemicals, 2 summers. War service in Navy over 2 yr. Single. Age 28. No disability. Available March 1. Salary open. W-381-69

AGRICULTURAL ENGINEER interested in design, development, research, sales, or service in power and machinery field with industry. Midwest location. Willing to travel. BS deg in agricultural engineering, 1951, Kansas State College. Farm background with Army Corps of Engineers in flood control work, 3 mo. Enlisted and noncommissioned service with Engineer Combat Battalion 2 yr. Single. Age 24. No disability. Available now. Salary open. W-394-70

AGRICULTURAL ENGINEER interested in extension, teaching, research, sales, or service in power and machinery, farm structures, or soil and water field with industry or public service in Northeast. BS deg in agricultural engineering, 1952. Farm background. Electronic testing one year. U.S. Forest Service 3 mo (precollege). Design and development with farm equipment manufacturer 16 mo. War enlisted and noncommissioned service 18 mo, in rail transportation. Married. Age 25. No disability. Available on reasonable notice. Salary open. W-378-71

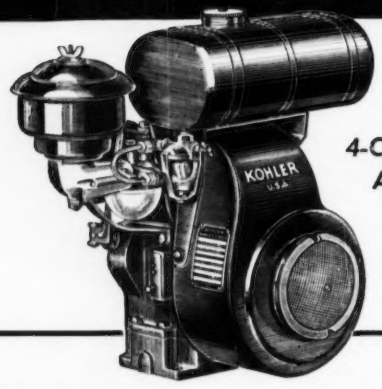
AGRICULTURAL ENGINEER interested in design, development, research, or service in power and machinery or rural electric field with industry or public service, anywhere in U.S.A. Trained in agricultural mechanical engineering, States School for Engineering, Cologne, Germany, completed July 1953. Farm background. Farming apprenticeship one year. Farm machinery operation and maintenance in wheat and sugar beet production, one year. Engine fitting and machine tools for gearing, 2 mo. Single. Age 23. No disability. Available Jan. 1 (after immigration for permanent residence in U.S.A.). Salary open. W-398-72

AGRICULTURAL ENGINEER interested in design, development and research in power and machinery field, with industry or public service. Any location. Willing to travel. BS deg in agricultural engineering, 1951, A & M College of Texas. Working toward MS deg in agricultural engineering with minor in mechanical engineering. Research experience in farm machinery 2 yr. Extension work in farm structures one year. Pregraduation experience as part-time draftsman. War enlisted and commissioned experience in Navy, 3 yr. Married. Age 28. No disability. Available February 1 or on minimum of 30 days' notice. Salary open. W-350-73

AGRICULTURAL ENGINEER interested in design, development, and research, soil and water field, with industry. Some preference for location in Canada. Limited travel. BS deg in agricultural engineering, 1949, University of Saskatchewan. Experience 4½ yr with Dominion government, including 2½ yr on small water development; one year on hydraulic and hydrologic computations for flood control and related design; half year on writing, revising, and final editing on flood control reports; half year on preliminary reports and design on drainage aspects of large reclamation project. Present rating GR 2. Married. Age 25. No disability. Available on 30 days' notice. Salary $4300-$4500. W-404-74

AGRICULTURAL ENGINEER interested in design, development, research, or management, power and machinery field, with college or industry. Any location, some preference for South. Travel if necessary. BS and MA degs in agricultural engineering, 1941 and 1947, Alabama Polytechnic Institute. Graduate assistant 2 yr. Manager of farm equipment dealership since October 1947. War commissioned service 4½ yr in Field Artillery, with promotions to Major. Married. Age 35. No disability. Available on 45 days' notice. Salary open. W-426-75

KOHLER ENGINES



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Power for garden tractors, mowers, pumps, sprayers, snow removal equipment, elevators and hoists, mobile saws, concrete mixers, compressors, feed grinders, industrial and lift trucks, and a wide range of tools and equipment for industry, construction, farm and home.

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For Complete Information . . . write for Bulletin 58

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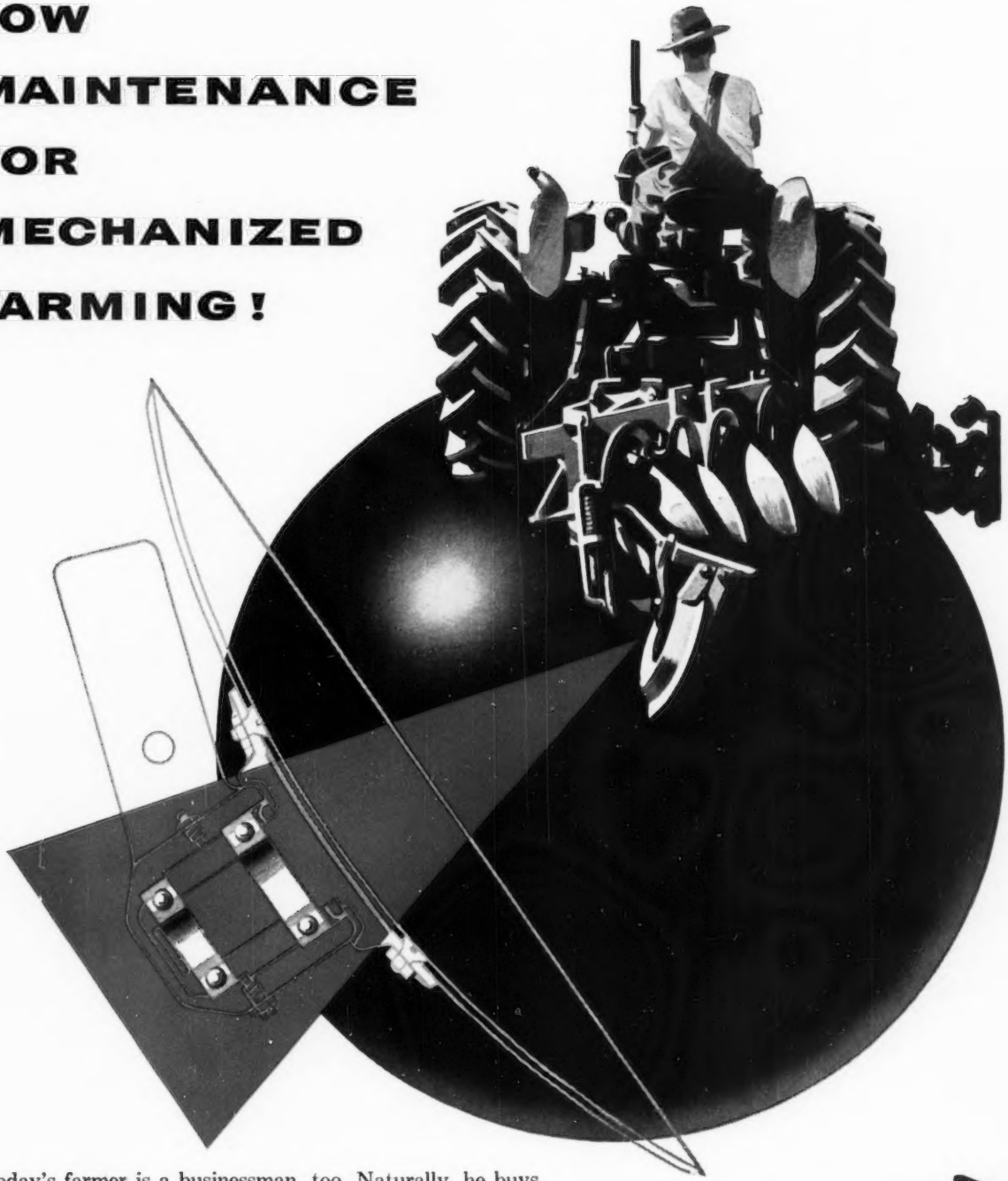

Today's farmer is a businessman, too. Naturally, he buys the equipment that lowers costs and gives him the greatest return for every dollar. That's why more and more designers of farm machinery are specifying New Departure ball bearings. For New Departures support moving parts with rigid accuracy—with the very minimum of maintenance!

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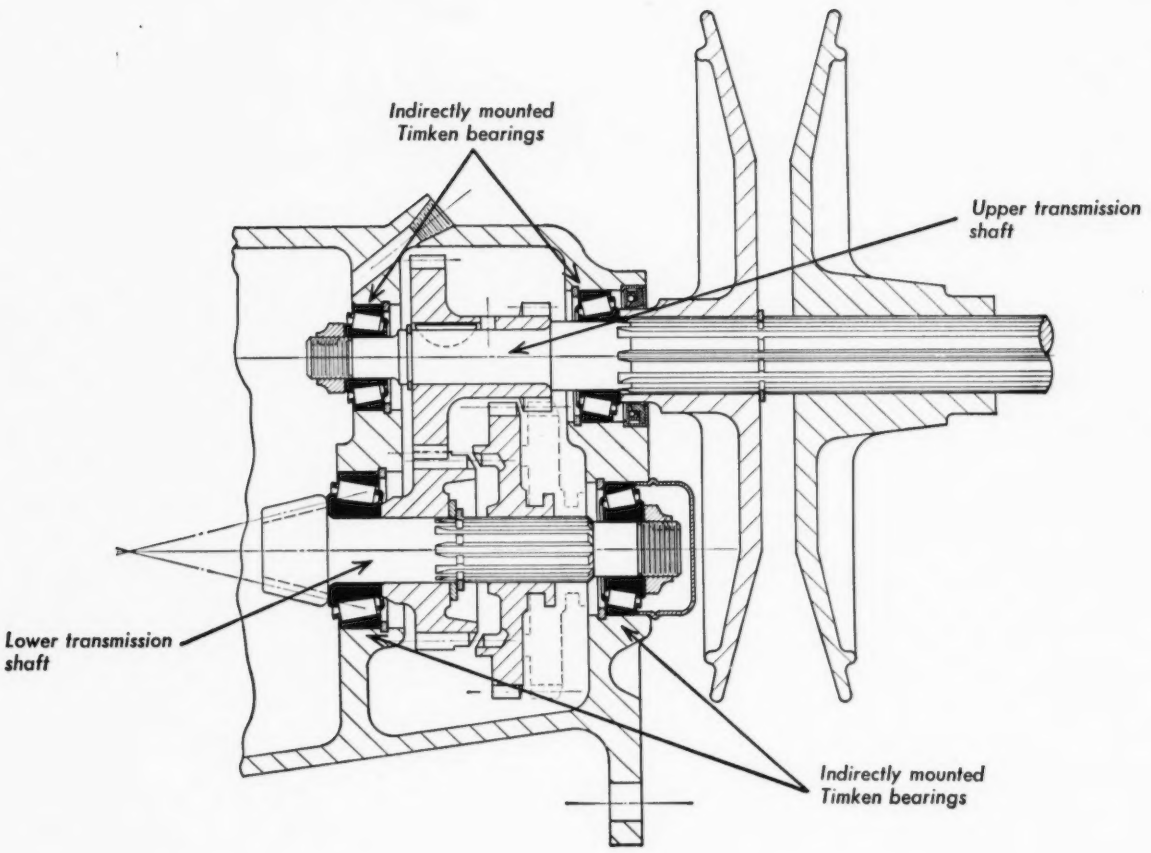
EVERY MAKE OF FARM TRACTOR HAS TIMKEN BEARINGS; MORE AND MORE IMPLEMENTS ARE USING THEM, TOO!

Indirect Mounting of Timken® Bearings Achieves 4 Economies in Combine Transmissions



THIS self-propelled combine transmission uses indirectly mounted Timken® bearings on the upper and lower transmission shafts. This eliminates a bolted-on bearing cap and results in these four big savings: 1) cost of the cap, 2) cost of milling the end face of the unit, 3) cost of drilling and tapping screw holes, 4) cost of the holding screws.

Because of tapered construction, Timken bearings easily take the wide range of radial and thrust loads in self-propelled combine transmissions and auxiliary drive mechanisms. Shafts are held in positive alignment, assuring accurate gear mesh and a smooth flow of power. And Timken bearings hold housings and shafts concentric, making seals more effective. Dirt and moisture stay out—lubricant stays in.

With Timken bearings, implement engineers can solve three of their biggest design problems: 1) dirt, 2) combination loads, 3) ease of operation. And implement users are assured of longer implement life, less chance of breakdown in the field, higher speeds and less frequent lubrication.

For more information about Timken bearings, write now for your free copy of "Tapered Roller Bearing Practice in Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

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NOT JUST A BALL ◯ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬮ AND THRUST ⟷ LOADS OR ANY COMBINATION